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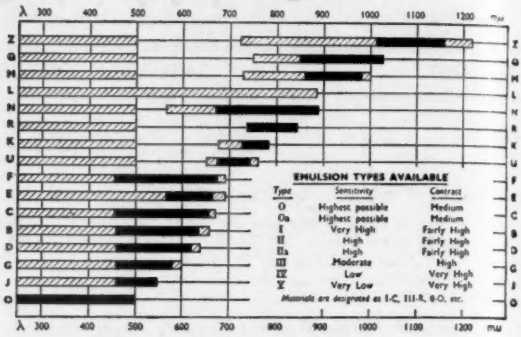

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DEVELOPMENT OF INDUSTRIAL RELATIONS IN BRITAIN

THE wave of official and unofficial strikes in Britain in the earlier months of this year, and the official warnings which have been given in the late summer regarding inflation and Britain's balance of trade, have raised many questions about Britain's economic and industrial position. Apart altogether from the issues which arise out of the development of automation to which reference has already been made in *Nature* (**176**, 133; 1955), the adequacy of trade union organization has been brought into question by the inter-union disputes, and a series of further wage claims has aroused widespread misgivings as to the possible effect on the economy of the country. The level-headed and realistic way in which the Trade Union Congress dealt with such questions, including automation, at Southport, has done something to restore confidence and dispel the excessive sense of confidence in our economic affairs. Prof. J. R. Hicks's presidential address to Section F (Economics) at the British Association meeting was also reassuring in its suggestion that British trade unions have already learned that it is wiser to advance wage-claims on bases other than the profits of the employer, and that the rise in money-wages since 1945 is not a necessary consequence of full employment, but is explicable in terms of factors peculiar to the time through which we are passing, particularly the dismantling of the controls and the difficulty experienced in establishing a new pattern of relative rates after the war-time disturbance.

Mr. Alec Rodger's presidential address to Section J (Psychology) was also reassuring in indicating some of the resources available for dealing with the important problems of the effective use of man-power and human relations in industry, while Prof. J. H. Richardson has contributed to a recent issue of the *Westminster Bank Review* a useful survey of the main causes and significance of the wave of official and unofficial strikes, in which he also considers the practicability of various remedies. Despite the economic losses and grave inconvenience to the British public caused by strikes since the middle of 1954, the average annual losses from strikes during the twenty years 1935–54 amounted to less than the equivalent of one hour's work in a year by the whole body of work-people. This favourable record is attributed by Prof. Richardson largely to the sense of responsibility shown both by trade union leaders and representatives of employers' associations, and their recognition that industrial peace is vital to their own interests and to the economic welfare of the country.

It is obviously important to avoid disturbing this sense of responsibility; and though complicating factors have made the settlement of wage disputes more delicate and difficult, particularly because unions have failed to agree on a policy, Prof. Richardson emphasizes the desirability of weighing this when considering any changes proposed. The essential basis of British industrial relations is the regulation of wages and working conditions by voluntary collective agreements, concluded after joint negotiation between trade unions and employers' organizations. This system of collective bargaining has given excellent results during the past twenty-five years; but it implies the right to strike or lock-out in the last resort. To take away those rights and prohibit the right to strike because, as Prof. Richardson shows, there have been a number of recent strikes which were called without reasonable time for conciliation and where the settlement reached could easily have been made without a stoppage, would involve setting up an authoritarian system alien to British traditions. Nor would it be certain to eliminate the risk that workers would go on strike and that the State might in consequence be forced to adopt methods of ruthless repression.

Prof. Richardson suggests drawing a distinction between strikes against the provisions of a duly negotiated and signed collective agreement, and strikes arising out of a breakdown of negotiations on the terms of a new agreement. To declare the former illegal would strengthen the trade union movement and would not restrict the basic right to strike. It would not stop unofficial strikes, but it might reduce their number.

The proposal that a strike should only take place when the decision is supported by a majority of those concerned as shown as a result of a secret ballot is, Prof. Richardson points out, a matter for the individual trade unions. It is already the rule in many unions, and could with advantage be adopted more widely; but it could not be regulated effectively by law. Similarly, the remedy for unofficial strikes really lies within the trade union movement, including measures of discipline against the ringleaders who have flouted the authority of the union, for which measures, indeed, the rules of many trade unions already provide.

Prof. Richardson sees no dramatic solution for these problems of industrial relations. Improvement depends on the cumulative effect of a many-sided attack. Structurally, the organization of some trade unions may require improvement so as to improve the contacts between the union officials and their members, just as better contacts are also needed between representatives of employers and the leaders of the unions. The Trades Union Congress has already taken some measures to restrict conflicts between rival unions; and while it may be necessary to make better provision for the formation of new unions if contact between officials and rank and file is to be vitalized, this also is a reform which must come from within. The present rigidities and complexities cannot be corrected from outside, though public opinion could play some part if better information were made available so that the issues could be understood at an early stage.

To make fuller information quickly available for public opinion to understand the issues and indicate

its attitude could also help in the settlement of particular disputes; but, as Prof. Richardson observes, leaders on both sides must recognize that, though they retain the weapons of industrial warfare, those weapons should be used so rarely as to become almost obsolete if fair dealing is shown in negotiations. Moreover, on the rank and file of the trade unions rests the obligation of loyalty to their leaders and of avoiding being led astray by irresponsible agitators. Equally, the leaders must show themselves more aware of the outlook and feelings of the rank and file. It should not be impossible to provide appropriate safety-valves, consistent with the rules; these are obviously desirable to discourage the formation of splinter groups. Indeed, if the trade unions were made less rigid and liberalized, even to the extent of permitting any body of workers which genuinely desired to leave one union for another, or to form an entirely new union, to do so in an orderly constitutional manner, there might well be less dissidence and discontent even if no new unions were actually formed.

There can be no mistaking the demands which any attempt to make trade union organization less rigid and more adapted to the industrial conditions of to-day will make on rank and file as well as on officials. So far as the official is concerned, the demands will be comparable with those made on the management side of industry. Few unions have yet made any attempt to give their shop stewards, for example, the kind of economic training which would enable them to take a responsible part when negotiations at the plant-level become necessary, or to bring the shop steward into vital touch with headquarters. The demands for leadership and training are not made on one side of industry only, however; Dr. W. H. Scott has recently pointed out that greater care should be taken to see that those appointed to managerial posts possess administrative ability and a capacity for consultative leadership, and that those appointed to senior posts should be required to undergo a course of study of administration. Similar considerations apply to the trade unions.

If the excessively bureaucratic tendencies of some trade unions are to be checked, and a balance achieved between the necessary measure of centralized administration and the no less desirable development of local initiative and responsibility, similar criteria must be applied to the selection and training of full-time officials. The delegation of greater responsibility to lay representatives by the unions is essential if we are to achieve industrial democracy and eliminate the misunderstandings, strains and restrictions which have played so large a part in engendering recent disputes; but it cannot be obtained or used creatively without appropriate attitudes on the part of officials. That in itself involves a break with existing practices in recruitment, and seeking much more widely and energetically for the kind of people who are capable of discharging responsibilities in a democratic way and exercising consultative leadership.

Apart from this, as discussions on automation have recently indicated, deficiencies in management ability or a restrictive outlook on the part of the union official can easily hinder the enjoyment by the workers and the public of the benefits of advances in industrial technique or improved managerial practice. The trade union official, in fact, needs increasingly an education comparable in rigour with that required by the industrial manager if he is to meet the demands made on him for judgment, administrative ability and technical knowledge, as well as for hard, constructive thinking. This is a further reason why, as Dr. Scott pointed out, we must encourage the development of educational institutions outside industry, as well as promote policies within it and within the unions whereby such people can be produced as well as discovered.

Here, then, this need for a new outlook on the recruitment, training and promotion of the trade union official, as well as on the function and policy of the unions themselves in conditions of full employment, touches on social and educational institutions generally. We must be concerned to see that they are such as to encourage the formation of personality and further the higher level of education demanded on the part of the rank and file, as well as the greater demands for education and training required by the trade union official even to discharge his primary responsibilities to members of his union. Further, it will not be enough for the unions to recognize their public responsibilities. The major responsibility for avoiding industrial disputes lies with management; and though there is much to be done by the unions within their own organizations, management still has a primary responsibility for the improvement of industrial relations, and helping to create the conditions favourable for the trade unions to effect their own internal reforms.

How this can be done and the way in which the two sides interact was well brought out by Mr. Alec Rodger in his address at Bristol. Of the five basic elements in a human relations policy which Sir Walter Monckton emphasized at the International Labour Conference last June, the provision of information and perfection of the art of communication are pre-eminently a managerial responsibility. Mr. Rodger asserted that it is sadly neglected in Britain. Although we cannot hope to plan methodically and well without facts, we have much to do here, especially in regard to vocational guidance, before we have eliminated a serious cause of wasted man-power.

Vocational guidance, like wise selection of personnel, can be a potent means of avoiding friction, frustration or discontent; but it is in regard to occupational training that a new outlook is most required. Mr. Rodger points out that later school-leaving is already depriving the apprentice system and the trade unions of many of the abler boys they need, through rules which are ill-adapted to the new educational system. Nor is it simply that many apprentices are not being efficiently trained. A minor man-power crisis looms ahead: for every two boys of high capacity leaving school to-day, there will be three in 1962. Fresh thinking is urgently required on the training of young people, especially for the

skilled trades and in the light of the implications of automation.

Mr. Rodger made no extravagant claims for the help which the psychologist or other scientist could give. He emphasized, however, as clearly as Prof. Richardson, the importance of dealing with the difficult problem of wage differentials; and in welcoming Mr. Hugh Gaitskell's desire to see such differentials based more securely on occupational differences in skill, responsibility, effort, danger and dirt, he pointed out that in studying these and other criteria the psychologist has a substantial contribution to make. Whether he can make it, however, depends on more than his ability to make his function clear, to formulate his questions well and to take a fuller part in industry itself. It depends equally on clear thinking about the respective functions of management, of the trade union official and of the other experts as well as about our ultimate purposes. We must have clear ideas as to their respective roles and define our objectives before we can see clearly how these contributions interlock in any one problem and what still remains to be done. There must also be clear understanding of why changes are required, and exactly what those proposed changes are intended to achieve, on the part of all concerned before we can hope to see them adopted and put into operation.

This implies a great task of education, within, as well as outside, the trade unions themselves. Much of it must be carried out by the unions, or at least with their active co-operation, if it is to be effective; but nevertheless other bodies can assist. Discussions like those at Bristol, and Prof. Richardson's paper, help to put the issues objectively and impartially before the public; and both the Press and broadcasting can play their part, not least by presenting the facts free from prejudice and distortion. Clearly the Workers' Educational Association could play an important part in promoting a re-valuation of the functions of the trade unions in the context of full employment and technological change, and developing an outlook favourable to adjustment and not to restriction; while apart from any place in such extra-mural activities, the universities, through their departments of social science, for example, can make a large contribution to the creative thinking required to develop new procedures and forms of organization.

Deeper still in this question of education lies the development of a sense of public responsibility. It is not enough for management alone to show a greater sense of responsibility towards all those employed in an industry and to the public whose interests that industry serves. The trade unions themselves must exercise a greater sense of responsibility towards the public as well as towards their own members, and must show clearly that the privileges which are theirs to-day are not used selfishly or unworthily but with a full sense of the public welfare.

That sense of responsibility was manifest at the Southport Congress at least on the part of many leaders and delegates; but it was no less clear that much has still to be done before the implications are fully understood by the rank and file, and the unions as a whole are ready to accept whatever measures may be required to prevent the abuse of power and disregard of public responsibility. The union leaders will need all the help which can be given them both in bringing home to their members the implications of the new position of their unions in the world to-day and in solving the difficult problems of union organization involved, if we are to retain the advantages of the big union in dealing with wage and like questions, and yet the understanding of local problems, whether in a particular firm or a particular area, where the small union or the shop steward has such an advantage. There is much experience which could be placed at the disposal of the unions to help them to work out their own solutions, and the studies already carried out by the Acton Society Trust or by Dr. W. H. Scott, for example, indicate that when the trade unions come to address themselves to the task of internal reform and re-organization, they can draw on concrete and impartial studies as well as an immense amount of public understanding and support.

CHEMISTRY AND BIOLOGY OF THE NUCLEIC ACIDS

The Nucleic Acids

Chemistry and Biology Edited by Erwin Chargaff and J. N. Davidson. Vol. 1; pp. xi+692; 16.80 dollars. Vol. 2; pp. xi+576; 14.50 dollars. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1955.)

DURING the few years preceding the outbreak of the Second World War it was the general opinion that the chemical nature of both deoxyribonucleic acid and ribonucleic acid had been almost completely elucidated. Some anomalies, it is true, remained; but these did not seem to disturb unduly the main conclusions. Important developments, however, then occurred in the biological field. Stanley discovered that certain plant viruses were nucleoproteins containing ribonucleic acid—a result which suggested that nucleoproteins, wherever they occurred and whichever type of nucleic acid they contained, constituted biological self-reproducing units. This was followed by Caspersson's and Brachet's demonstration, the former using ultraviolet spectrophotometry and photography and the latter histochemical methods, of the widespread occurrence of ribonucleic acid in the cytoplasm of animal and plant cells and, in particular, of its high concentration in those cells in which protein synthesis could be assumed to be taking place. Finally, there came Avery's discovery, not only that the principle which transformed the rough form of Type II pneumococcus into the smooth form of Type III was a deoxyribonucleic acid, but that also this substance was specific to Type III pneumococcus. It thus became evident, first, that ribonucleic acid was much more widely distributed in Nature than had previously been thought and, secondly, that species specificity, with all its implications, might exist among the deoxyribonucleic acids of higher organisms, despite the overt or tacit rejection of this idea by earlier workers.

Doubtless as a result of these developments, the past decade has witnessed a renewal of investigations,

both from the chemical and biological aspects, into the nucleic acids which, if one is to judge from the bulk of literature that it has produced, have been carried out with an intensity hitherto unknown in this field. It is the object of the present work, which consists of two volumes, to give an up-to-date and detailed account of the nucleic acids in the light of these recent researches. The two volumes are devoted respectively to the chemistry and biology of the subject.

As a perusal of the first volume shows, the last word on the chemistry of the nucleic acids has not yet been spoken. Nevertheless, many substantial achievements, particularly in the development of experimental techniques, are recorded. Thus, the isolation of deoxyribonucleic acid, if not of ribonucleic acid, is now a relatively simple, if tedious, process; the application of paper chromatography, associated with the use of ultra-violet spectrophotometry, has provided a method for the determination of the bases present in both types of nucleic acid with an accuracy previously totally unattainable; and the isolation of nucleotides from hydrolysates of the nucleic acids, an operation which was so laborious and gave such uncertain results when the older chemical methods were used, can now be effected more readily and with greater certainty both by ion-exchange chromatography and by paper ionophoresis. When the use of the classical methods of organic chemistry and of specific enzymes which bring about the step-wise degradation of the nucleic acids or their hydrolysis products is combined with these newer techniques, as they have been, it is not, perhaps, surprising that some of the old conceptions of the nature and composition of these substances have been abandoned.

Nevertheless, a very substantial amount of the older work remains valid. In particular, the fundamental conception of the nucleic acids as a chain of nucleotides united together by ester linkages between the phosphoric acid group of one nucleotide and a hydroxyl group of the carbohydrate of the other still holds, as do the structures assigned to the individual nucleotides. But results with the new techniques have certainly demonstrated that the nucleotides are not combined together in equimolecular proportions, as was formerly believed and expressed in the tetranucleotide theory. They also include many other achievements, among which are the discovery, in minute amounts in the deoxyribonucleic acid from animal sources and in larger amounts in that from wheat germ, of a fifth nucleotide containing 5-methylcytosine as base; the finding that the deoxyribonucleic acid of a number of bacteriophages contains 5-hydroxymethylcytosine instead of the customary cytosine; and the precise determination of the positions of the internucleotide linkages in both ribonucleic and deoxyribonucleic acids. The question of the species specificity of the nucleic acids has, however, not yet received a definite answer. That there exist different deoxyribonucleic acids, particularly among the micro-organisms, has been abundantly proved both by chemical and biological methods. Moreover, as the results mentioned above show, the deoxyribonucleic acid from wheat germ appears to be different from that from animals. But it would, in my opinion, be taking too optimistic a view of the overall accuracy of the analytical processes employed to conclude from the later and more accurate figures obtained with animal deoxyribonucleic acids that these are species-specific. This opinion is reinforced by the evidence provided by, among others, one of the editors of this work that the nucleic acids are not homogeneous. Should this evidence be confirmed, it will clearly considerably diminish the value of the mass of analytical data which has been published on the composition of deoxyribonucleic acids from various sources.

Advances in the biological field, described in the second volume, represent steady progress rather than spectacular achievements. Thus, Avery's original discovery has been extended; the widespread occurrence of ribonucleic acid in biological material, particularly in the cytoplasm of animal cells, has been confirmed by numerous analyses; measurements have been made, using various types of cells from different species, of the weight of deoxyribonucleic acid in single nuclei, the results being interpreted as indicating the presence of a constant amount of this substance in the nuclei of all diploid, and half that amount in haploid, cells of each species; and a start has been made, using the isotope tracer method, in ascertaining the nature of the precursors used in the biosynthesis of the nucleic acids.

Dealing, as they do, with these and many other aspects of the nucleic acids, the two volumes of this compilation give, on the whole, a very complete and up-to-date account of the nature and occurrence of the nucleic acids and of their chemical, physico-chemical and biological properties which will be invaluable to all working in this field. It will doubtless become the principal, if not the only, modern reference-book on the subject. This statement does not, however, mean that the whole work is uniformly excellent. This would not, indeed, be expected of a treatise the twenty-eight chapters of which embody the contributions of thirty-four authors. There are, in fact, many criticisms, of different degrees of importance, which might be made. Of these, I have selected three which I feel bound to make.

Owing to its size, the price of the work will render it inaccessible to individuals except through libraries. By more careful selection of the subject-matter and by the pruning of redundant material, this result could have been minimized to the benefit both of the reader and of the finances of libraries. For example, Chapter 2 is a monograph of seventy pages on ribose and deoxyribose. Most of the details which it contains belong to carbohydrate chemistry and must surely be included in the literature of that subject. It therefore seems superfluous to reproduce them here. Chapter 3, dealing with the purines and pyrimidines, is to some extent susceptible to the same criticism, but it serves better, by quoting the following sentence from it, to illustrate how far the subject-matter of the work may in places digress from the nucleic acids: "In 1943, the important discovery was made that the administration of alloxan to rabbits leads to the necrosis of the insulin-producing units of the pancreas (the β-cells of the islets of Langerhans), thereby providing a tool for the production and study of experimental diabetes".

The greater the objectivity with which a scientific treatise is written, the more valuable will it be. In my opinion, such objectivity is not always present in the discussion in Chapter 17 on the use of the Feulgen reaction for the quantitative determination of deoxyribonucleic acid in biological material. The author should have made it clear that, for obvious reasons, this reaction is never used for the estimation of deoxyribonucleic acid *in vitro*. He should also have discussed experiments which have shown that, at

any rate when one commonly used fixative is employed, considerable quantities of nucleic acid are lost from cell nuclei during the period of hydrolysis required to produce maximum intensity of staining by this method. Instead of doing this, he is content to brush objections to one side and to regard the method as justifiable because it usually yields the desired results.

Chapter 18 is not the authoritative article which purchasers of this work are entitled to expect. The author dismisses my work with the remark: "Unfortunately many of the conclusions drawn by the Stedmans from their experimental data . . . are, in the opinion of the writer, highly questionable" without so much as mentioning the nature of the conclusions or of the data on which they were based; and this is not the author's sole lapse in propriety.

E. STEDMAN

SCIENTIFIC BASIS OF MEDICINE

Lectures on the Scientific Basis of Medicine

Vol. 2, 1952–53; pp. xi+380+29 plates. Vol. 3, 1953–54; pp. iv+398+9 plates. (British Postgraduate Medical Federation: University of London.) (London: Athlone Press, 1954. Distributed by Constable and Co., Ltd.) 35*s*. net each vol.

THESE two volumes continue the publication of the yearly series of lectures, begun in 1951, under the auspices of the British Postgraduate Medical Federation. In his preface to Vol. 2, Sir Francis Fraser, director of the Federation, explains that the topics of these lectures are selected by a committee as being ripe for presentation to an audience of young medical research workers and junior consultants and specialists. The lecturer invited to deal with each topic is a person actively engaged in furthering advance in it by original research. Sir Francis points out that the lecture syllabuses are not a mere haphazard tour around a changing scene, nor can any single annual syllabus properly be treated as an isolated entity. Each course is planned as a stage in an integrated, continuously developing survey which can only yield its full value to the student who keeps himself continuously familiar with it. It is to enable students to do this that the Federation provides these annual published volumes. Not all the lectures delivered are published; in part because accessible summaries exist, in part because their topics, though presentable in lecture form, are not yet ready for evaluation in print. Vol. 2 contains nineteen out of thirty-six lectures delivered, and Vol. 3 twenty-one out of thirty.

It is of interest to survey these volumes in the light of Sir Harold Himsworth's recent Linacre Lecture (*Brit. Med. J.*, ii, 217; 1955) on "The Integration of Medicine". They provide a partial answer to Sir Harold's plea for more comprehensive postgraduate study, and they illustrate well the difficult task of those engaged in such education to present briefly and in readily understandable form the rapidly growing and ever more specialized topics that to-day form the basis of medicine. The lectures range over chemistry, biochemistry, physics, physiology, genetics, bacteriology, virology and zoology. They are for the most part simply and interestingly written. They provide not only the junior, but also the senior postgraduate workers (whose need is almost as great) with helpful surveys of the advances in knowledge in many fields relating to medicine. It is permissible to question, however, if undergraduate medical education is now of the nature to produce more than a small proportion of young graduates sufficiently 'groundedly learned' fully to appreciate the material here offered for their understanding.

In view of Sir Harold's fear about the diminishing recruitment of medically qualified men to the non-clinical branches of medicine, it is heartening to see that, of the forty lecturers in the two volumes under review, twenty-eight are medically qualified. Moreover, a glance at the list shows that, as Sir Harold desires, they are men of authority, and no less than eleven are distinguished as Fellows of the Royal Society.

R. T. GRANT

THEORY OF JET FLOW

Fluid Dynamics of Jets

By Prof. S. Pai. Pp. xv+227. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1954.) 37*s*. 6*d*. net.

THE theory of jet flow is a natural offspring of boundary-layer theory; but until recently it lacked, unlike its parent, the stimulus of important practical applications. During the past decade, however, the development of jet propulsion has profoundly modified the aeronautical picture, and the study of jet flow has acquired great practical significance. Jets can be used to propel aircraft, to provide lift, to assist boundary-layer control and generally to modify the aerodynamic characteristics of surfaces near which they pass or from which they emerge. Thus, there arise three main topics of interest: the flow in jets, the effects of jets on neighbouring surfaces, and the interaction of jets. Prof. S. Pai's monograph is concerned almost exclusively with the first topic, for the good reason that only the flow in jets has yet received sufficient attention to provide ready material for a book.

The book deals essentially with theoretical developments, and its appeal to the practical engineer is likely to be limited. Much of the material is not new; but it has important sections never previously published in book form, and the book is noteworthy as the first in English devoted exclusively to jet flow. Its presentation is, in the main, logical and straightforward, although occasionally the arrangement of some items is surprising. It covers very extensive ground, and therefore some important subjects are given little more than a brief mention; an initial glance at the table of contents is apt in such cases to raise unfulfilled hopes.

The first three chapters are concerned with jets of an inviscid fluid, one chapter being devoted to an incompressible fluid and two to subsonic and supersonic flow of a compressible fluid. Much of this material is classical but is none the less interesting. The remainder of the book deals with jets of a viscous fluid. The fourth chapter is concerned with laminar jet flow for both compressible and incompressible fluids, and the following two chapters deal similarly with turbulent jet flow. Here the limitations and inadequacies of mixing-length theories are fully discussed; but these theories are applied extensively in view of their success in providing useful relations of proved validity for incompressible fluids. Inadequate warning is given, however, of the difficulties in extending these theories to compressible flow.

Thus, equally plausible assumptions can lead to widely divergent results, and the available experimental data offer as yet little empirical guidance. These chapters include a brief discussion of the more important aspects of the statistical approach to turbulence and a very inadequate reference to the important topic of jet noise. An interesting chapter follows on the mixing of jets of different gases where diffusion becomes important, and the last two chapters deal with the stability of jets of incompressible and compressible fluids. The theory is presented in some detail, but more might have been made of the results. In an appendix the fundamental equations of fluid dynamics are briefly derived.

The writing lacks grace, and there is an irritating economy in the use of the definite article as well as an occasional misprint. Nevertheless, the book is clearly and honestly presented and should be welcomed by the many aeronautical scientists concerned with jet flow.

A. D. Young

ENERGY FROM THE SUN

Applied Solar Energy Research

A Directory of World Activity and Bibliography of Significant Literature. Edited by E. J. Burda. Pp. ix+298. (Stanford, Calif.: Stanford Research Institute, 1955. Published for the Association for Applied Solar Energy.) n.p.

RESEARCH on the utilization of solar energy has been greatly stimulated during recent years, and rapid developments have been made in the United States and other countries. There is an increasing realization that such applications will play an important part in the future co-ordination of world energy resources, and an Association for Applied Solar Energy has been formed at Phoenix, Arizona. As a preliminary stage in its programme to encourage research, this Association has issued the first international directory and bibliography of solar research as a record of what has been done in the past and is being attempted in the present.

This publication is much more than a mere list of references; under headings of countries, Part 1 lists the universities, other organizations and individual research workers who are engaged in solar energy activities, with brief summaries of the work in progress. Although the United States section contains more entries than all other countries together, there is evidence of an active world-wide interest in this subject. Short details are given of solar symposia that have been held since 1950, including particulars of the World Symposium on Applied Solar Energy which is to be held this November in Phoenix, Arizona.

Part 2, constituting the remainder of the volume, is a bibliography containing nearly fifteen hundred references, with short abstracts in most cases. These references are numbered and arranged in alphabetical order; and the numbers are rearranged in a cross-reference of classified subjects—for example, distillation, heaters, insolation, photo-synthesis, to give a few examples. The information is invaluable not only to those engaged in active research, but also to those commencing a study of the subject. Library facilities and staff for this publication were provided by the Stanford Research Institute under the general direction of Merritt L. Kastens, with the co-operation of Dr. Marie Telkes, of New York University.

H. Heywood

TECHNOLOGY OF TITANIUM

Titanium in Industry

Technology of Structural Titanium. By Stanley Abkowitz, John J. Burke and Ralph H. Hiltz, Jr. Pp. x+224. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1955.) 36*s*. net.

THE development of the three structural metals of this scientific age—titanium, magnesium and aluminium—has not, in terms of the span of human life, been fast. In each of these cases, from being initially recognized in the laboratory, until equal recognition was attained in the industrial world, a period of time varying from three-quarters to rather more than a century and a half has elapsed. Seemingly, but not paradoxically, because the metallurgical difficulties involved were very great, titanium, the first of this little group to be discovered, has taken longer to acquire engineering status than the other two. In 1789, its existence was clearly realized by the Rev. William Gregor. The metal did not, however, attain a position in engineering until the present decade. It—or more exactly, some of its alloys—was then shown to have a combination of qualities, such as low specific gravity when compared with iron; mechanical properties (up to about 300° C.) comparable with those of alloy steels; and, in a large number of media and in particular in sea water, a quite outstanding resistance to corrosion. These characteristics made it suitable for applications where performance, rather than cost, was the primary consideration. This is, of course, the case in the aircraft gas-turbine field.

In a book of slightly more than two hundred pages, divided into ten chapters, the authors attempt to cover the production of the metal, its chemistry and physics, and manipulation in mill, forge and workshop of both it and of some of its many alloys. The task they have thus undertaken is a formidable one. Their book is of necessity superficial. It is not, however, inaccurate, and indeed has merit. It contains more than twenty excellent photomicrographs and some good graphs in relation to a number of the mechanical properties of some of the many titanium alloys. With regard to their fatigue and creep characteristics, however, the treatment is disappointing. This is unfortunate, for it is these qualities which are of the utmost importance in the field in which the metal and its alloys are at present finding their greatest application. Against this criticism, it is but fair to state that the work is, in most respects, up to date. For example, the authors disclose, as has only recently been appreciated, the unexpected but tremendous influence of hydrogen on titanium. In excess of a hundred parts per million, this gas, which markedly alters the microstructure of the metal, is deleterious. When the metal contains double this amount, a number of undesirable characteristics, for example, grave reduction in such essential engineering properties as ductility, impact and fatigue resistance, may well arise.

To conclude: anyone having a somewhat detached interest in titanium and its alloys will find this well-produced book, in spite of its relatively high cost, a worthwhile introduction to a very large subject. On the other hand, should the potential reader be already involved in the production and/or use of titanium and its alloys for structural and/or mechanical purposes, it will often prove wanting—due to the magnitude of its scope, it inevitably lacks depth.

P. L. Teed

THE NEW SCHMIDT TELESCOPE OF THE HAMBURG OBSERVATORY

By Dr. O. HECKMANN
Director

DURING the summer months of 1954, a new Schmidt telescope was installed at the Hamburg Observatory in Bergedorf, some fifteen miles east of the city of Hamburg. The instrument was under test during the succeeding ten months, and on August 19 and 20 its dedication was celebrated by an astronomical meeting in Hamburg devoted to various matters of technique, method and programme related to the new type of telescope. The instrument was already planned in 1936, when Dr. W. Baade, of Mount Wilson Observatory, was to become director of the Hamburg Observatory, to the staff of which he had belonged during 1920–31. The instrument was tentatively designed to have an aperture of 80 cm. and a mirror of 100 cm. diameter with a focal length of 160 cm. (f : 2). But Baade stayed in Pasadena because a still larger Schmidt telescope was to be put at his disposal, the 48-in. (=120 cm.) Schmidt of Mount Palomar (f : 2·5) completed after the War. The Hamburg instrument could not be realized until, in 1948, the German currency recovered. The original plans were somewhat changed by increasing the diameter of the mirror from 100 cm. to 120 cm. and the focal length from 160 cm. to 240 cm. ; so its dimensions are about two-thirds of the Palomar instrument.

The design of the Hamburg instrument has been influenced by that of its larger Californian counterpart, but there are some noteworthy differences. The first is the fact that a double tube was chosen, so as to avoid flexure of a magnitude that could cause deterioration of the definition of the optical images when an objective prism of some 400 kgm. is put in front of the correcting plate. Indeed, when moving the instrument from zenithal to horizontal position the correcting plate is shifted by less than 0·1 mm., which is very satisfying. Secondly, there is an automatic temperature compensation of focus ; this is provided by three rods regulating the distance of the mirror from the plate-holder but—and here is the difference from the Palomar 48-in.—using rods of approximately the same high thermal inertia as that of the mirror. In order to avoid very rapid temperature changes, the whole tube is protected by a felt cover 15 mm. thick covered with canvas. Thirdly, the mounting is of the fork type ; but the fundamental idea is to have all movable parts supported exactly below their common centre of gravity. This is achieved by making the centre of gravity the centre of a sphere, part of which consists of a ground steel zone of 2 m. radius, at the base of the very heavy yoke of the fork. Fig. 1 demonstrates this better than any verbal explanation. The steel zone rests on self-adjusting oil pressure-bearings ; so the adjustment of the polar axis of the instrument is carried out without working against gravity.

The instrument is moved by electrical controls into any desired position by means of 'Selsyn' motors. The two guiding telescopes can be adjusted so that their flexure relative to the main tube vanishes. They are easily accessible by means of a car which, by an electrically driven hydraulic piston, can hoist a platform with the observer. He can control all motions of the car from his seat. A hydraulic lever can be substituted for the platform when the mirror is to be taken from the instrument for aluminizing.

Whereas the mounting of the instrument was manufactured in the machine tool works of Heidenreich and Harbeck in Hamburg, the optics and the tube were made by C. Zeiss of Jena. In spite of the political tensions between the east and west of Germany, the two firms found a reasonable way for their mutual collaboration.

The mirror consists of the low-expansion glass *ZK*7, the correcting plate and the 4° prism of glass *UBK*7, which is transparent to the ultra-violet. The optical quality of the prism has not yet been investigated. The properties of the system mirror plus correcting plate are as follows : In the extremely steady air of the Zeiss laboratory, we could estimate visually that distances smaller than 0·5″ could be resolved. When used for celestial photography, unsteadiness of the air and the diffusion of light in the emulsion become of increasing influence, so that the smallest star images on the average are about 2·5″, that is, about 30μ. So we may say that the performance of the instrument is limited by the seeing conditions and not by its optical quality. The

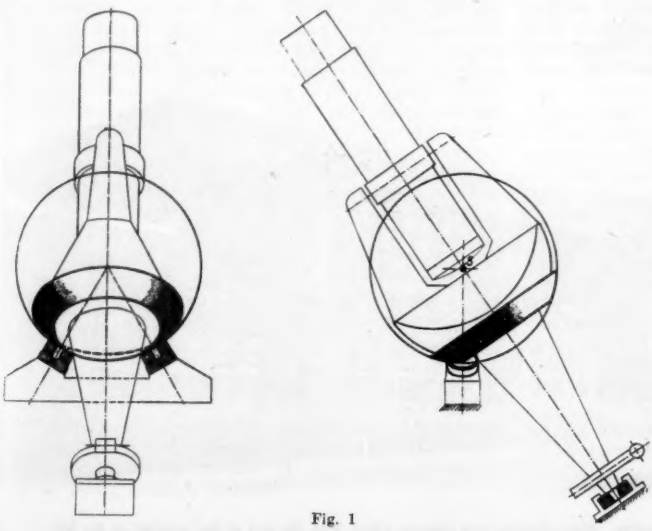

Fig. 1

square plates cover a field of 5° × 5°. If they are not thicker than 1 mm. they never break when bent to a sphere of 2·4 m. radius, as is necessary in all orthodox Schmidt telescopes not using field lenses.

As regards the observing programme with the instrument, I feel somewhat uneasy because of the wealth of problems which eventually can be undertaken; so I hesitate to say much. The most serious danger is to begin programmes which can be easily photographed but which are difficult to evaluate on account of the enormous amount of information afforded by a single intelligently taken photograph.

We plan to work on galactic clusters, known as well as hitherto unknown. Work on variable stars is also possible. Further, we are interested in the distribution and colours of extragalactic nebulæ. In addition, the objective prism makes possible a search for several kinds of special stars. Further, should the number of plates threaten to overwhelm us, we shall be glad to pass on material to astronomers who are willing to evaluate it.

VETERINARY MEDICINE AT CAMBRIDGE

By Prof. L. P. PUGH
Professor of Veterinary Clinical Studies

THE Cambridge School of Veterinary Medicine is derived substantially from ideas and recommendations contained in the two reports of the Loveday Committee on Veterinary Education in Great Britain (1938, 1944). Before this, however, in 1923, a chair of animal pathology had been established, and Prof. J. B. Buxton appointed as the first professor and director of the Institute of Animal Pathology. Later, in 1935, the University, in consultation with the Royal College of Veterinary Surgeons, proposed a scheme for courses in the preclinical subjects which would lead to certain exemptions from the examinations for membership of the Royal College and to a postgraduate diploma, after qualification and registration had taken place, the final two years being spent at one of the existing veterinary schools. The first report of the Loveday Committee approved the 1935 scheme; but in 1944 the same committee decided to go further and recommended that all veterinary schools in Britain should become integral parts of universities. It also proposed that a School of Veterinary Medicine should be located at Cambridge which would provide both pre-clinical and clinical training, and would lead to a degree in veterinary medicine. These recommendations were accepted by the Ministry of Agriculture and by the University.

In 1947, the chair of animal pathology which Prof. T. Dalling had vacated during the War was filled by the appointment of Prof. W. I. B. Beveridge, and he became the director of the Institute of Animal Pathology. This Institute continued actively to pursue research into the diseases of animals. In 1949 the Institute became a department within the Faculty of Biology 'B' of the University.

In 1950, the present writer was appointed as the first professor of veterinary clinical studies, to organize a new Department within the Faculty of Medicine. These studies were to comprise all those subjects usually included under the broad headings

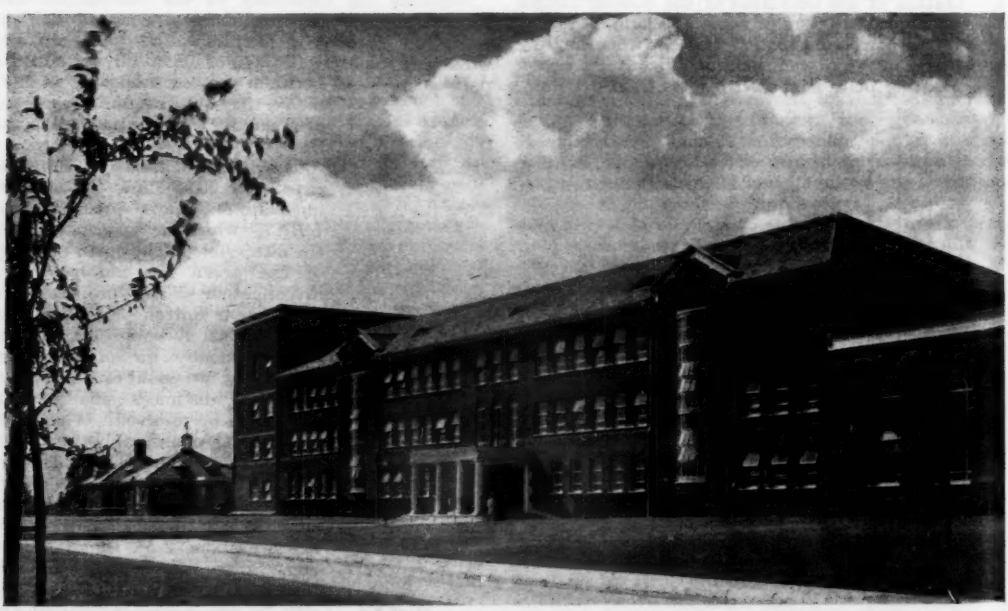

Fig. 1. The Veterinary School, Cambridge. Main teaching and research block, with the end of the hospital on the left

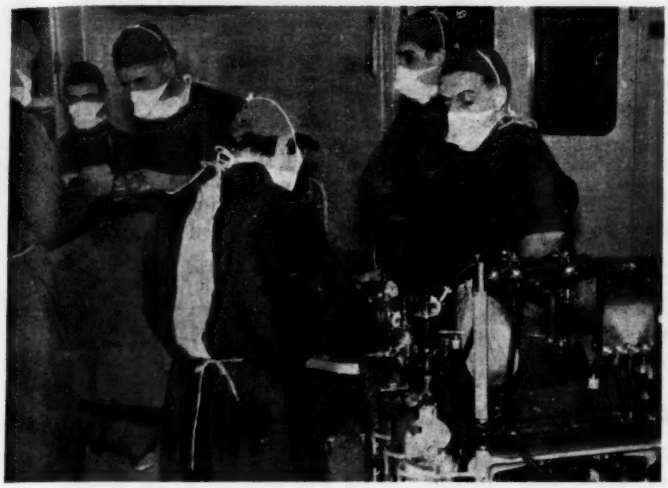

Fig. 2. Unposed photograph of an operation on a dog in progress

of animal health, animal surgery and veterinary medicine.

The buildings of the new Veterinary School, which were opened by H.M. The Queen on October 20, are located within two miles of the city centre on about one hundred and twenty acres of farm land. Here the Departments of Animal Pathology and Veterinary Clinical Studies are ideally situated both for teaching and research into the diseases of livestock and, at the same time, are able to maintain a close association with the other cognate sciences.

There are obviously two pre-requisites for teaching and research into veterinary problems: (1) an adequate supply of normal animals, for the study of the maintenance of health; and (2) an ample supply of clinically affected animals. The first requirement was met by getting together a dairy herd, sheep, pigs, ponies, and poultry in suitable numbers. These farm animals provide material for studies of the normal which, for the student, must precede an introduction to the sick. The techniques of the physical handling of animals, their management singly or in groups, nutrition with all its variations, breeding, pregnancy and parturition, observations of behaviour and the functioning of the healthy body, production of milk, and so on, are exercises conducted for purposes of training. The second requirement, clinical material, has been met largely by providing a veterinary hospital service to the practitioners in the surrounding counties. Operating theatres, rooms for radiology and other specialized types of examination of patients have been set up and are now in full use on a consultative basis. A large clinical-pathology section has been formed in the Department of Veterinary Clinical Studies which will act as the natural liaison between that Department and the Institute of Animal Pathology.

Team research into the disease problems of farm livestock will constitute an important part of the programme of the School. Already research into such varied subjects as virus pneumonia of pigs, hæmolytic disease of the new-born, parasitic diseases of cattle and sheep, respiratory and other diseases of birds, are all being actively studied.

The establishment of a veterinary school, fully functioning in all its varied interests, must certainly take time. Building delays have unfortunately resulted in the first graduates of the Cambridge School obtaining their degrees before the completion of the teaching block. Those that follow them will reap the benefit of being able to work in the finished buildings in which all the interests of the Departments have been congregated.

Prof. Pugh has set forth his aims and ideals in his inaugural lecture given in Cambridge on March 8*. He traces the inception of the idea of a school for clinical veterinary studies to Sir Clifford Allbutt, regius professor of physic in the University of Cambridge for thirty-three years until his death in 1925. Allbutt constantly advocated a *rapprochement* of studies relating to the diseases of man and animal. In Oxford there was a similar movement due to Sir Henry Acland, regius professor of medicine there. The first step towards this end was the establishment of a chair of animal pathology in Cambridge; but there the matter rested until shortly before the Second World War, when a scheme for veterinary education similar to that followed by medical students was prepared. This opened the way to fulfilment of the recommendations of the Loveday Committee.

Clinical studies, broadly speaking, comprise preventive and curative medicine. Preventive medicine has arisen largely from a knowledge of causal agencies, and it has led to an appreciation of the social significance of human medicine and the economic significance of veterinary medicine. With the decline in economic importance of the horse, the interest of the veterinarian has turned towards farm animals and their place in agriculture. In curative medicine similar methods have been applied in both human and veterinary medicine. But the practical side of veterinary medicine must depend more on economics than sentiment, and will increasingly lean towards the maintenance rather than the restoration of health—that is, preventive medicine.

The knowledge of the clinician is based on the advances made by workers in many branches of natural science, mainly in university institutes; and his tendency to become an empiricist must be resisted. The exact observation and measurement of disease and the experimental study of its processes must not be separate disciplines. Here the veterinarian has an advantage, in that experimental conditions can be maintained. Nevertheless, the veterinary hospital functions as any other teaching hospital, and the ethical obligations and limitations are comparable to those accepted in human medicine and surgery.

The common ground existing in the study of disease processes in man and animals is the attempt to interpret disease in terms of function and func-

* "Veterinary Clinical Studies at Cambridge". By Prof. L. P. Pugh. Pp. 26. (Cambridge: At the University Press, 1955.) 2s. 6d. net.

tional co-ordination. To place the Department of Veterinary Clinical Studies in the Faculty of Medicine of the University of Cambridge is thus a step towards the comparative approach to medicine. The clinician has already learned to go to the pathologist and biochemist for aid, and it is regrettable that he has not turned more often to the physiologist. The latter works particularly with the dog and the cat—two animals with which the veterinarian is concerned—and it is time that many of the findings with laboratory animals should be extended to the farm animals.

Prof. Pugh concludes as follows: "Basically there are two problems. Is there a place in the intellectual structure of this University for a clinical department, and is there a place for a veterinary school? I hope that the opinion advanced may at least 'provoke those it cannot convert'.

"I have tried to express the aim that veterinary medicine must develop its own science of experimental medicine; I have suggested an approach to this problem in the hope that not only will it enlarge our understanding of disease, but will make for a closer relationship with the other scientific disciplines and create a logical sequence of ideas in teaching. In pursuing this object, the veterinarian's interest in different animals suggests that it is ultimately by a comparative approach that a clinical department can best play its part in the furtherance of knowledge and that, by this approach, the fundamental similarities and dissimilarities between species, in which I include man, may be profitably exploited".

CAVITATION IN HYDRODYNAMICS

CAVITATION is a subject of growing scientific and technical interest, and the first international symposium to be devoted entirely to it was organized by, and held at, the National Physical Laboratory, Teddington, during September 14–16. The word itself was coined sixty years ago by R. E. Froude to describe the process which he visualized as responsible for the unexpectedly poor performance of high-speed propellers fitted to a naval vessel just then completed; his imaginative speculation that the very low pressures existing in some regions of the flow through the propeller caused the formation of cavities in the water was soon shown to be correct by Parsons, and since then naval architects have frequently been concerned to detect and overcome the harmful effects of this breakdown in homogeneous flow. The same problems were later found to occur in hydraulic machines, and more recently cavitation phenomena have become important in such different fields as ultrasonics and underwater projectiles and explosions. This has naturally led to more detailed study of the basic mechanism of cavitation, and during the past few years much has been learned about the behaviour of individual cavities and the factors which control their inception, while considerable progress has also been made in understanding the nature of erosion damage due to cavitation.

It was because of this recent increase in research on cavitation problems that it was considered appropriate to hold a symposium at Teddington to discuss the progress made; because of the special interests of the Ship Division of the National Physical Laboratory, the problems of cavitation in hydrodynamics were selected for special examination, and the programme of the meetings was designed to proceed from discussion of the fundamental physics of the phenomena to consideration of the hydrodynamic effects of cavitation on performance and damage, and to methods recently developed for their study. The symposium was divided into six half-day sessions, at the first of which an opening address of a general nature was presented, while the other five sessions, at which a total of twenty papers was given, were each devoted to a different aspect of hydrodynamic cavitation. In addition to these formal meetings, a further informal session was arranged during the symposium to meet the wishes of those particularly interested in ultrasonic cavitation for a discussion of their problems. A total of about a hundred and thirty delegates from fourteen countries attended the meetings, of whom more than half took an active part as authors of papers or as contributors to the discussions. Special care was taken to give adequate time during the sessions for discussion by firmly limiting each author to fifteen minutes when presenting his paper, and several of the ensuing discussions were extremely lively and instructive. The symposium proceedings, including summaries of these discussions, will be published by H.M. Stationery Office in about six months.

The opening address, given by Mr. P. Eisenberg (United States Office of Naval Research), was a critical review of recent progress in cavitation research, and discussed the origin and stability of entrained gas nuclei and their effects on inception, the influences of turbulence and boundary-layer flow conditions, the present knowledge of the dynamics of transient and steady-state cavities, and the status of research on theories of cavitation damage. He concluded that during the past few years there have been two main accomplishments: the basic problems have been more sharply defined, and the physical phenomena that must be considered in their investigation have been more clearly identified. Mr. Eisenberg emphasized that the questions awaiting answer for immediate engineering application are the very ones which require an understanding of some of the most complex and least understood phenomena in hydromechanics. The chairman, Dr. J. F. Allan (superintendent of the Ship Division of the National Physical Laboratory), commended this conclusion, and forecast that developments in ship propulsion would bring cavitation into more prominence and accentuate the need for practical solutions to its difficulties.

The second session, with Dr. R. W. L. Gawn (superintendent of the Admiralty Experiment Works) as chairman, was concerned with the factors governing inception of cavitation. The effects of dissolved and entrained gas content, the ability of water to sustain considerable tensions under dynamic conditions, and the growth of gas nuclei, particularly those in boundary-layer flows, were the main topics of discussion. It was clear that a means of determining the spectrum of entrained bubble size in flowing water was much needed, and that acoustic methods, often used as criteria of cavitation inception, offer possibilities in this direction. This discussion led naturally to the consideration of experiment techniques, the subject of the next session, at which Prof.

W. P. A. van Lammeren (Netherlands Ship Model Basin) was in the chair. Instruments for measuring fluctuating forces, pressures and velocities and others specially developed for new Admiralty large-scale test facilities were described, while one paper gave details of high-speed photographic methods (with pictures taken at rates of up to 1 million per second) designed for studies of individual bubbles in ultrasonic cavitation, which have a life-cycle, during which intense collapse pressures are generated, encompassed in 1 μsec. A paper outlining the performance characteristics of a small experimental water tunnel led to a vigorous discussion of the virtues of re-absorption devices (inelegantly but widely known as resorbers) in large-scale cavitation testing rigs. Many new water tunnels, including a large new propeller tunnel to be built for the National Physical Laboratory, incorporate expensive resorbers, and the general consensus of opinion seemed to be that these are desirable provided sufficient money is available.

Even large test facilities for ship propellers and water turbines can only handle models which are small compared with their prototypes, and thus scale-effect factors are of great importance in cavitation studies. The papers at the fourth session of the symposium, under Prof. J. W. Daily (Massachusetts Institute of Technology), dealt with this thorny problem, and the relative importance of the significant parameters, particularly the Froude, Reynolds and Weber numbers, was discussed. One paper gave some disturbing preliminary results from a series of geometrically similar model propellers, and another showed remarkable Admiralty photographs of propeller cavitation patterns taken during ship trials of a destroyer and other naval vessels. The following session, with Mr. F. S. Burt (Admiralty Research Laboratory) as chairman, was concerned with a related problem—the effects of cavitation on the hydrodynamic performance of foils. Valuable data on the properties of hydrofoils under super-cavitating conditions (when fully developed, steady-state cavities spring from the leading edge) were given in a group of papers and supplemented in the discussion. A pleasant, and valuable, interlude here was an excellently produced film, with full colour and sound, showing some of the pioneering work being done at the California Institute of Technology. Finally, the delegates turned their attention to the vexed question of cavitation damage, and the papers delivered at this session presented very different views on the mechanism of damage erosion, the upholders of the two schools of impingement attack and corrosion fatigue being in evidence. The qualities of cathodic protection as a damage inhibitor, and the role of gas in water as a damage 'cushion', were also argued. The damage potential of cavities of fixed type, shown to have a fiercely periodic nature with violent downstream collapse conditions, was also brought out; and if this session cannot claim to have resolved the opposed views, it certainly did much to clarify them. Mr. Eisenberg, chairman at this session, persuaded Prof. J. Ackeret (Zurich), a pioneer in this field, to remind the delegates of some highly pertinent effects of shock waves in causing damage, and in his own closing remarks commented that the programme of the symposium had clearly brought out the central problems for discussion. Dr. Allan, responding for the National Physical Laboratory, regretted that the delegates had had to remain almost silent on the problems of cavitation noise; but hoped that in spite of this the meetings would encourage further research which would extend our knowledge and control of cavitation phenomena. Dr. Allan felt that this research should not be organized on an internationally agreed programme, perhaps not even on a national basis, but that individual workers should pursue their own interests and meet at intervals to exchange views. This suggests that the first conference on cavitation problems will be followed by others.

A. SILVERLEAF

DEATH AND THE AFTER-LIFE

THE general theme, "Disposal of the Dead, and Beliefs in an After-Life", was selected as the main part of the programme of Section H (Anthropology and Archæology) at the recent Bristol meeting of the British Association, because experience had shown the need for a common topic about which anthropologists and archæologists desired each to hear what the others had to say, and the theme chosen provided scope for participation by nearly all elements in the section. With one or two exceptions, the papers were grouped in the sessions as indicated by the headings.

From the Origin of Man to the Mesolithic Period

The evidence from pre-Neolithic peoples was discussed in the opening session by Dr. Kenneth Oakley, Mr. Miles Burkitt and Dr. L. H. Wells. In his paper on "Earliest Evidence of Disposal of the Dead", Dr. Oakley remarked on the tendency, among gregarious non-human primates, for the dying animal to leave the sleeping-place of the troop. He then dealt with cannibalism, which was widespread before disposal of the dead by ceremonial or careful burial became regular. All the remains of Pekin man in the Choukoutien cave deposits are judged to be the debris of cannibal feasts. The bones of Neanderthalers in the Krapina cave appear to have been deliberately broken, and many were charred; the female skull from Ehringsdorf shows evidence of mortal blows; the breaking of the Steinheim skull was evidently deliberate, and all the eleven Solo (Ngandong, Java) skulls have their bases and facial bones missing as if broken for extraction of their brains. The base of the Neanderthal skull found within a ring of stones on the floor of the Goat's Cave in Monte Circeo has clearly had the foramen magnum enlarged for this purpose. Therefore, it appears that head-hunting and brain-eating were characteristic of these early periods.

Mr. Miles Burkitt then dealt with "Middle and Upper Palæolithic Burials". It was not only the 'old man' of the family, but also women and children who were carefully buried. At La Chapelle aux Saints, it is true, there was only one burial of a man in a sepulchral cave, with evidence that the interment had taken place with care and ceremony; but at La Ferrassie the whole family were buried in what presumably had been their home, with care and possibly some sort of ritual, as the body of one of the children was covered by an artificially cup-marked stone. Other Mousterian burials are known. Whether the reason for this care for some of the

dead was fear or love, or a belief in some sort of after-life, we can never know. The burying of implements and bones of animals with the dead would seem to suggest that the mourners thought the dead might need these at some time.

In Upper Palæolithic times we also have plenty of evidence for careful burial; and here, too, discoveries suggest that some sort of ceremony occurred at the interments. Cro-Magnon and Chancelade are sites to mention, as well as some burials at Mentone where the body of the male occurs laid out with his head on a stone pillow, and partly covered with pierced shells. The female was entirely covered with unpierced shells. In most cases ochre was sprinkled over the bodies—possibly imitating life-blood.

The practice of careful burial continued into Mesolithic times. Apart from elaborate burials, such as Ofnet (where, as Dr. Wells later mentioned, severed heads probably imply ritual head-hunting), there is plenty of evidence of simpler procedure but yet indicating careful burial—as at Hoëdic, Téviec, Nugem and Axpea.

Dr. L. H. Wells concluded the first session with a review of the pre-Neolithic evidence from Britain, and in the course of his paper described the Cheddar skeleton as the finest Upper Palæolithic cave-burial in Britain, and expressed the view that some of the skeletons from Aveline's Hole (Mendip) were definite burials. The Mesolithic population of Britain may well have been derived from Upper Palæolithic groups.

Evidence from Living Primitive Peoples

The funerary customs of living primitive races were discussed by Dr. R. M. Berndt, Dr. Jack Goody, Mr. G. W. B. Huntingford and Mr. Hitoshi Watanabe. Dr. Berndt being abroad, his paper on "Cannibalism in the Eastern Central Highlands of New Guinea" was read by Dr. Goody. Cannibalism was described as "a most nourishing and hygienic means of disposing of the dead", the practice of which is common and not abnormal in the area described. The Eastern Highlanders of New Guinea put much emphasis on warfare, and are somewhat careless of death. Behind this attitude, however, is a belief in an after-life, in reunion with the original creative beings, and eternal residence in some kind of spirit world, or alternatively in rebirth. The newly dead are considered to have much the same needs as the living, and when they appear to their kin in dreams, it is often to ask for food, warmth or fire.

Eating human flesh is not confined to members of one sex, nor is it restricted to eating one's own kin, or members of the same district or village. Men do not hesitate to eat the flesh of a female, or women that of a male, while an enemy is eaten just as readily as a member of one's own kin. People avoided eating victims of the dysentery epidemic which followed the Second World War. Human meat is regarded primarily as food, and not eaten to absorb the power or strength of the deceased.

Dr. Goody's paper was on "Death and Social Control among the Lo Dagaa of the Gold Coast". He expressed the belief that "the conflict between the mortality of the human body and the immortality of the body politic is resolved by the belief in a future life". Only situations of rapid social change can admit scepticism in this field. Lo Dagaa beliefs include punishments meted out by the Ferryman at the River of Death to debtors, witches, thieves, and to those who have refused legitimate requests. There are also the punishments inflicted in the Land of the Dead by the high god himself. The Lo Dagaa funerals are dual, consisting of: (i) the mortuary ceremony (disposal of the body), and (ii) subsequent ceremonies (connected with eschatological beliefs). Orientation of the body differs for men and women, and childless adults have a form of burial different from those who have had children. The temporary deposit of grave-goods is known among this tribe.

Mr. G. W. B. Huntingford spoke on "Nandi Beliefs in a Future Life". In common with many other East African tribes, the Nandi of Kenya rely on the hyæna to dispose of their dead. A hyæna must not be looked in the eyes in the daytime (according to the Nandi), because the spirit of a dead person may be looking through them. Every person is believed to have a shadow-soul which dies with him, and a heart-soul which passes with the body into a hyæna and finally enters the spirit-land underground. This spirit-land is considered to contain trees, grass, hills, water, sun and moon, as in this world. The spirits are believed to have cattle and grow wheat: yet there is the incompatible belief that they live on the goods provided by the living. Grave-goods placed with the dead are removed from the tomb after one day, to be re-used by the living.

The final paper on living peoples was given by Mr. Watanabe on "Disposal of the Dead by the Ainu of Japan". According to the Ainu, the dead are met in the underworld by a watch-dog; from the underworld the fire-god sends the good dead to the (upstream) village of deities, and the bad dead to the (downstream) wet underworld. The welfare of the dead depends partly on correct observance of rituals and taboos by the living, who practise them carefully, since good spirits can confer punishments and blessings on the living. The corpse is dressed in clothes which are worn inside-out (an excellent example of reversal of procedure for the dead, met with also in parts of Oceania). Food is offered first to the fire-god, then to the dead, and finally it is eaten by the mourners. After the funeral feast, the corpse is extended with head upstream. All the grave-goods are ceremonially broken to release their spirits to accompany the dead to the after-life. Both tomb and grave-goods are covered with magical twigs and plants to keep away evil spirits. Post-funerary rites are performed after the dead are considered to have reached their destination. (It is hoped that Mr. Watanabe's paper will be published in full in *The Advancement of Science*.)

Evidence from American Archæology

Evidence from South and Central American archæology was outlined in papers by Dr. G. H. S. Bushnell and Mr. Adrian Digby. Dr. Bushnell, dealing with ancient Peru, referred to the two main traditions of burial, both dating back at least to the formative period in the first millennium B.C. The first (north coast) was of recumbent burials, at first generally flexed but sometimes extended, and later almost without exception extended. A gold plaque in the mouth is frequent, and bamboo tubes for food offerings, extending to the surface of the ground, occur but are rare. The second tradition (south coast and southern highlands) had bodies seated in a crouched posture and generally wrapped in textiles to form a bundle, which may have a false face. The richer burials in both areas were elaborate, the

southern mummies being wrapped in many layers of textiles, some richly decorated. The Tiahuanaco expansion spread the southern tradition over the whole coast and it prevailed everywhere until the Spanish conquest.

There seems to have been at all times a belief in the continued being of the body or at least of the bones. In Inca times it was believed that nobles and good commoners went to a happier life with the sun, and bad commoners went to hunger and misery within the earth; but the mummies were treated with the consideration appropriate to a living person. This points to a belief in a soul apart from the mummy.

Burial and the after-life among the Maya of south-east Mexico and adjoining areas between about 100 B.C. and A.D. 900 were considered by Mr. Adrian Digby. He referred to their elaborate ceremonial centres embodying temples, courts and pyramids, in some of which burials have been found. For example, at the bottom of the pyramid below the Temple of Inscriptions at Palenque in Mexico, there was a sarcophagus decorated with the design of a tree symbolizing life and rebirth, resembling that shown springing from a wounded victim on a pre-Columbian Maya manuscript. Belief in immortality is suggested by certain practices, such as modelling the features of the dead in bitumen on the skull; deposit of red ochre with some important burials; deposit of jadeite beads, perhaps to serve as money in the after-life; and occasional ceremonial killing of vessels placed with the dead.

Evidence from Egyptian Archæology

Dr. Margaret Murray, doyen of Egyptologists, in an address memorable for its clarity of exposition, confined her review of Egyptian funerary evidence to the prehistoric and predynastic material. The Badarian burials were single, flexed as in sleep, facing the west—the Land of the Dead. The Amratian burials were communal, contracted, and again faced the west. A few exceptions may have belonged to a special cult or been foreigners. The body was sometimes dismembered, and in certain instances the head was removed and either a pot or an ostrich egg substituted. In other instances the head was preserved on its own. Gerzean burials tended to be single, contracted, and in deep graves. Lastly, those of the Semainean culture were usually single and contracted, often in wooden coffins. The bones were sometimes disarranged and piled in square heaps. A skull cult, perhaps involving scooping out the brain, was not unknown in predynastic Egypt and continued in later times.

Evidence from British Archæology

The remaining sessions were devoted to a consideration of the British evidence from the Neolithic period almost to the present day. Dr. H. N. Savory drew upon some recent excavations in his paper on "Communal and Separate Burial in Neolithic Britain"—a paper which covered two distinct though partly overlapping cultures between 2000 and 1500 B.C. Dealing mainly with the evidence from the south-west, he stressed the rarity of articulated corpses in long barrows, caused probably by transfer from a temporary deposit elsewhere. Deliberate breaking and rearrangement of bones suggested that fear of haunting played a part in the cult. In separate burials, solicitude for the after-life is more clearly indicated by richer grave-goods, food offerings and occasional ritual breaking of the objects rather than the bodies. The encircling wall or ditch of the round barrow defined the ceremonial precinct and may be related to 'henge' monuments, although the latter were not primarily sepulchral.

"Inhumation and Cremation in the British Bronze Age, and Related Beliefs" were handled by Mr. L. V. Grinsell against the background of the less fragmentary evidence from the Ægean, Scandinavia, Brittany and elsewhere. He gave instances of occasional substitution for grave-gifts of representations of them, and of ceremonial funerary breakings. The grave-goods we find when barrows are opened are only the more durable of those originally placed with the dead, and it is only in accidental circumstances that the perishable objects are preserved—as in the tombs of the Altai region in western Siberia, where preservation was due to freezing.

In describing "Beliefs in the After-Life in Iron Age and Roman Britain", Prof. I. A. Richmond explained how "the classical world impinged upon the prehistoric, and studied the barbarian world for its own sake while tolerating native custom within its own wide borders". This renders a separation between Iron Age and Romano–British beliefs almost unreal. Wine-filled tombs of Iron Age chieftains in East Anglia match the beliefs of Trimalchio ("Let me enjoy [the funeral wine] now!"), while Mommsen's Lingonian chief, cremated with his hunting gear, would have understood the hunting scenes on tombstones of later Pictland. Higher beliefs are reflected in Plutarch's traditions from the Western Isles or by St. Cuthbert's vision of Aidan's soul. In Roman Britain, tombstones portraying daily life reflect belief in survival of a personality thus recorded, as does the "Agricola". Cavalry tombstones of victory over barbarians have more in common with Rhineland monuments commemorating victory over death. The funeral banquet refers both to after-life and ancestor-worship. As subsidiary decoration, sphinxes and lions typify death, pine-cones immortality, vines and *amorini* the Dionysiac mysteries. The soul's journey to the Blessed Isles is suggested by Tritons or dolphins.

Disposal changed from almost universal cremation to burial, less for economic reasons than because of growing belief in individual survival. Special care for the corpse is represented by the gypsum-filled coffins at York, while the Dionysiac idea of death as sleep is evoked at Chester by the figure of a sleeping child.

Dr. H. R. E. Davidson followed with an account of the funeral customs of the Anglo-Saxons, "the first people in the British Isles whose funeral practices can be studied in the light of their literature". Archæologically, nearly all the earlier practices recur in this period: cremation, partial cremation, ritual fires, food offerings, funeral feasts, mutilation of the body, real and symbolic grave-goods, animal sacrifice, ship-funerals, etc. According to Snorre Sturlason, the higher the smoke from the pyre, the more lofty the position of the dead in heaven. There is evidence for ritual fires with inhumations as well as cremations. The body was often beheaded and may have been mutilated in other ways. Broken grave-goods occasionally occur.

The period from Anglo-Saxon times to the present day was covered by Miss Violet Alford and Mr. Grinsell. In her paper on "Dance and Song in con-

nection with Funerary Rites", Miss Alford mentioned the continuance of *pleureuses* in the Pyrenees, Mexico, Co. Kerry and elsewhere, and referred to the 'wakes' at funerals in the British Isles. Funeral dances were usually the current regional dances—jigs and reels in Ireland, reels and country dances in Scotland. Folk memories of barrow-burials live in folk-song and ballad. Denmark shows examples of a son obtaining a magic sword from his father's barrow, and the visit of 'royal maidens' to dead men in their 'earth-house'. "The Unquiet Grave", a well-known English folk-song, recounts the visit of the dead man to his sweetheart, who is disturbing his rest by her excessive grief.

"The Survival and Recurrence of Primitive Funerary Beliefs and Customs in Recent Times" was the title of the concluding paper given by Mr. Grinsell, who directed attention to the occasional recurrence of ceremonial breaking of grave-objects at funerals in the Ægean and even in Britain; the placing of coins in the mouth or hand of the dead; and the placing of white (generally quartz) pebbles on graves. Shakespeare's reference ("Hamlet", Act V, Sc. i) to the placing of "shards, flints, and pebbles" on the grave of a suicide suggests the survival of pre-Christian practices in such instances.

In an earlier paper which was not actually part of the general theme, Mr. L. Biek, of the Ministry of Works Archæological Laboratory, described the development of scientific techniques for obtaining evidence from burials, including the X-ray examination of a cinerary urn and its contents; examination of bronze implements to decide whether they had passed the funeral pyre; and study of 'silhouettes' of inhumations which have otherwise vanished.

A special exhibit to illustrate some main aspects of the theme was arranged at the Bristol City Museum, the aspects chosen being the ceremonial breaking of grave-goods at funerals; food offerings to the dead; the journey to the after-life (including the part played by the Ferryman of the Dead); the location and nature of the after-life; and the various methods adopted for the treatment of the dead.

The programme was concluded by Prof. E. O. James, who in his summing up indicated the change in emphasis from 'disposal of the dead' to 'beliefs in an after-life' from Upper Palæolithic times onwards. There is much archæological and anthropological evidence for belief in human survival; but the belief in immortality tends to involve more advanced philosophical concepts.

The results of the programme were felt to be eminently satisfactory. A full or large attendance was maintained throughout, and the percentage of younger people at the sessions was larger than for some years. Of the fifteen speakers present, eight attended all the sessions, three about half, and the remaining four came mainly to deliver their own papers, either breaking their holidays or in the midst of heavy commitments. Not a few of the audience came from other sections; but the most noteworthy result was the large number of archæologists and anthropologists whose minds became enriched by hearing the papers, and this applied both to the lecturers and to members of the audience.

I am grateful to all the speakers who kindly provided summaries of their papers, which have been used (together with my own notes) in preparing this account.

L. V. Grinsell

MANCHESTER COLLEGE OF TECHNOLOGY

GRANT OF A CHARTER

By Dr. B. V. BOWDEN
Principal

THE recent grant of a Charter to the Manchester College of Technology marks another important stage in the development of the College, which traces its history back to a Mechanics Institute founded in 1824 by eleven far-sighted Manchester business men, who each contributed £634 for the purpose. By 1905 it had acquired such a reputation at home and abroad that the University of Manchester created a Faculty of Technology which was incorporated in the College.

Thus for the last fifty years the College has discharged two quite separate and vitally important functions. It has trained full-time university students for university degrees, and it has also trained large numbers of full-time and part-time students in a variety of subjects which lead to qualifications other than degrees. This interesting association of university and non-university work will continue under the new constitution. The College will still be part of the University of Manchester, from which it derives so much of its academic strength. The standard of non-university work will be constantly raised by the elimination of the more elementary studies. Courses for Higher National Certificates will still be provided; but the most important progress in this section will be in the provision of part-time or short full-time courses of postgraduate or refresher type. By this means the developments which take place so rapidly in technology will be brought to the notice of engineers and scientists engaged in industry.

No other institution in Britain has quite the same association of university and non-university work, an association of the greatest importance in meeting the needs of industry for technologists of varied training and background.

The College has always been fortunate in the support which it has received from industry, and there are already signs that such support will be forthcoming on an even greater scale under the new regime. In return, the College will strive to serve industry by making available specialized equipment, by consultation with members of the staff on scientific and technical problems as well as by training personnel.

Situated in the heart of the most intensely industrialized area in the world, the College must play an important part in providing the increased number of highly qualified scientists and technologists essential for the national welfare. To achieve this purpose, further expansion will be necessary—expansion in

enrolments, in staff and in accommodation and equipment. A start has already been made; for the session 1953–54, 670 students were following full-time university courses in the Faculty of Technology. It was then planned to double this number by 1962 and a most encouraging start was made last October, when the number of new enrolments increased by 45 per cent; there is a further increase in the present session.

New chairs in municipal engineering, applied physics, industrial administration, textile chemistry and chemical engineering have been created, and more are envisaged.

Building extensions approved in 1928 are now coming into use; these extensions were, however, planned to relieve congestion existing thirty years ago, and further space is now essential. Preliminary steps have already been taken to provide a campus for the College and to meet future needs.

From small beginnings more than a hundred and thirty years ago the College has developed to its present stature, and it is confidently expected that, with the additional prestige bestowed by the Charter, its progress in the future will be no less remarkable.

OBITUARIES

Dr. R. C. L. Perkins, F.R.S.

Dr. R. C. L. Perkins, the distinguished entomologist, best known for his work on the fauna of the Hawaiian Islands, died on September 29 at Bovey Tracy, Devon, at the age of eighty-eight.

Robert Cyril Layton Perkins was born on November 15, 1866, at Badminton, Gloucestershire, the second son of the Rev. Charles Mathew Perkins. He was educated at the Merchant Taylors School in London. In 1885 he won an open classical scholarship to Jesus College, Oxford; but after two years at Oxford he changed to science.

In 1891 Dr. Perkins was chosen by a committee appointed by the Royal Society and the British Association to undertake an investigation of the land fauna of the Hawaiian Islands. For nearly ten years he worked strenuously for this committee, collecting material in all parts of the Islands. In 1899 his comprehensive volumes on the insect groups and birds began to appear in the "Fauna Hawaiiensis", and continued until 1913, when he completed the general introduction to the whole series. By this time he had already received the Linnean Society's Gold Medal for 1912.

During 1902–4 he worked for the Agricultural Department of the Territory in various capacities. But in 1904 the Hawaiian Sugar Planters' Association put him in charge of the new insect department of its experimental station. His work here with O. H. Swezey and F. Muir was mainly concerned with studying and controlling the pests of sugar cane, by introducing their natural parasites from their countries of origin.

Dr. Perkins was forced to retire in 1912 through ill-health acquired in the strenuous field-work under the exacting climatic conditions of Hawaii. He settled at Newton Abbot in Devon, but continued to work on his accumulated Hawaiian collections and to write about them for more than twenty years. He also continued his studies of British insects and made outstanding contributions to our knowledge of Strepsiptera, bees, crabronid wasps and sawflies. He was elected a Fellow of the Royal Society in 1920 and in 1951 an honorary Fellow of the Royal Entomological Society of London, of which he had been an ordinary Fellow for more than fifty years.

In 1901 he married Zoe, daughter of A. T. Atkinson, superintendent of public instruction, Honolulu, Hawaiian Islands; she died in 1940, and there are three surviving sons of this marriage. In 1942 he married Mrs. Clara Senior, of Highweek, Newton Abbot, and she died in 1949. His last days were sad ones, with blindness and failing strength. His loss will be regretted by the many who felt the inspiration of his genius and who experienced the encouragement he showed to those younger and less talented than he was.

Robert B. Benson

Mr. H. L. Kirke, C.B.E.

Mr. Harold Lister Kirke, formerly head of the Research Department and assistant chief engineer of the British Broadcasting Corporation, died in London on August 25 at the age of sixty. He served in the First World War as an officer in the Royal Fusiliers, the Signals Branch of the Royal Engineers and the Royal Corps of Signals. Later he joined the Marconi Company and was concerned with the early development of radio telephone transmitters. He was one of the small band of enthusiastic engineers who established the Writtle experimental broadcasting station in 1922, and two years later he joined the staff of the B.B.C. In 1925 he became head of the development section, which later became the Research Department of the Corporation; and in this capacity he was responsible for many of the technical advances made by the B.B.C. over the ensuing twenty-five years.

Important contributions were made by Kirke to the development of high-quality sound broadcasting at various stages from the studio through the transmitters and aerial systems to the technique of reception. Latterly, his study of the problems associated with sound broadcasting at very high frequencies was particularly valuable, and the decision of the B.B.C. to adopt the V.H.F. frequency-modulation system was based to a great extent on his research work.

Kirke was an active member of the Institution of Electrical Engineers; he was chairman of the Radio Section during 1944–45, and a member of Council from 1947 until 1950. He was also a Fellow of the Institute of Radio Engineers of New York, and was vice-president in 1952. He played a leading part in forming the Acoustics Group of the Physical Society, and was chairman of the Group in 1947. He was appointed C.B.E. in 1947.

Many of those engaged in radio research over the past quarter of a century will remember Kirke as an enthusiastic and pleasant companion at technical visits and demonstrations, and as a wise counsellor at meetings of boards and committees. It was with great sorrow that all his colleagues and associates learnt of his retirement through illness in 1952, two years after his appointment as assistant chief engineer of the B.B.C.

R. L. Smith-Rose

Lieut.-Colonel W. French, C.B.E.

Lieut.-Colonel William French, a member of the Council of the City and Guilds of London Institute, who was superintendent of the Institute's Department of Technology during 1934–49, died on September 18. Colonel French had had a varied career in the law, in the army during the First

World War, in the civil administration in Iraq, and in the iron and steel industry, before going to technical education. He joined the "City and Guilds" in 1929 at a time when the Institute was slowly recovering from the First World War. The subsequent remarkable expansion of its work until 1939 and the resumption of expansion from 1942 were largely due to his wise guidance. His major contribution was the building up of the Institute's system of advisory committees, where representatives of industry and education together plan and keep up to date the schemes of syllabuses and examinations upon which technical education, particularly at craft level, is based both in Britain and overseas. This advisory committee system transformed a rather rigid external examining body into an instrument sufficiently flexible to meet the developing needs of industry, yet sufficiently stable to maintain the high standards for which the "City and Guilds" has always stood.

Colonel French was especially successful in his personal relationships with the officers of the Board of Education and local education authorities, technical college staffs and those in industry (then fewer in number) who saw the need for better technical education. With his love of craftsmanship, his passionate concern for the well-being of young people, his transparent honesty and his pungent humour, he unobtrusively did much between the Wars in the technical education field to dispel misunderstanding and to promote that co-operation among technical examining bodies, teachers' organizations and professional and industrial bodies which nowadays is taken for granted. During the Second World War, though hampered by ill-health, he played a useful part in discussions preceding the drafting of the 1944 Education Act and, after the War, in the negotiations that ultimately led to the formation of the Associated Examining Board.

CYRIL LLOYD

NEWS and VIEWS

Atoms for Peace Awards

DR. JAMES R. KILLIAN, jun., president of the Massachusetts Institute of Technology, is to be chairman of the Organization and Planning Committee of Atoms for Peace Awards. In addition to Dr. Killian, the Committee will include Dr. Detlev W. Bronk, president of the Rockefeller Institute for Medical Research and president of the National Academy of Sciences; Dr. Ralph J. Bunche, Under-Secretary General of the United Nations; Dr. Arthur H. Compton, formerly chancellor of Washington University; Mrs. Douglas Horton, formerly president of Wellesley College; Dr. Mervin J. Kelly, president of the Bell Telephone Laboratories; and Dr. Alan Waterman, director of the National Science Foundation. The Atoms for Peace Awards, it will be recalled, were established last summer as a memorial to Henry Ford and Edsel B. Ford by a Ford Motor Company Fund appropriation of 1,000,000 dollars. It will provide 100,000 dollars annually for ten years to be spent in helping to provide incentives for the world's scientists, inventors and engineers—without regard for nationality or political belief—towards finding new ways in which atomic energy can be used for the welfare of mankind. It is now announced that the Executive Committee of the Massachusetts Institute of Technology has agreed that the headquarters of the new institution be located at the Institute. In inviting Dr. Killian and the Committee to undertake the planning and organization of the Awards, Mr. Henry Ford II expressed the hope that the Committee "would set up the organization of the Awards so that the organization would be an independent corporate entity, entirely separate and divorced from Ford Motor Company".

In informing Mr. Lewis Strauss, chairman of the Atomic Energy Commission, of the establishment of the new institution on July 25, Mr. Ford described it as a response to the hope expressed by President Eisenhower at the July meeting of the "Big-Four" in Geneva that "private business and professional men throughout the world will . . . provide an incentive in finding new ways that this science can be used . . . for the benefit of mankind and not for destruction". Mr. Ford said at that time, "We would propose that when the organization of this new memorial fund is completed, the Board of Trustees of Atoms for Peace Awards appoint each year a competent International Jury of Awards for the purpose of selecting from among the world's scientists, inventors and engineers—without regard for nationality or political belief—the individual or group of individuals who, in the Jury's judgment, has made the greatest contribution during the year to peaceful uses of atomic energy; that the individual or group so selected be granted with appropriate ceremony the Atoms for Peace Award for that year; that the annual Award carry, in addition to a suitable medal to be designed and cast for the purpose, an honorarium of 75,000 dollars; that, if during any year the International Jury of Awards or the Board of Trustees finds no candidates pre-eminently meriting the Atoms for Peace Award, the sum at the disposal of the memorial fund be used that year for scholarships and fellowships most likely to contribute to the advancement of the new science of peaceful application of atomic energy".

Massachusetts Institute of Technology: Prof. F. O. Schmitt

PROF. FRANCIS O. SCHMITT, at present head of the Department of Biology of the Massachusetts Institute of Technology, is relinquishing his post to take up the special appointment of Institute professor, and will be succeeded in the Department by Prof. Irwin W. Sizer, at present associate professor of biochemistry. The post of Institute professor is a special one designed to recognize outstanding achievement and to give its holder freedom to concentrate on research and advanced teaching; the only other person at the Massachusetts Institute of Technology who holds this rank at present is Prof. John C. Slater, the distinguished solid-state physicist. Prof. Schmitt's special field of study is in the use of the electron microscope for biological research, a field in which he became interested through his early work in X-ray diffraction and polarization optics for the study of the molecular organization of biological cells. After graduating from Washington University, St. Louis, in 1924, he did research work

there, and also in Berkeley (California), London and Berlin. He became head of the Department of Zoology in Washington University and then in 1941 he went to the Massachusetts Institute of Technology, the year in which the first electron microscope for use in an academic biological laboratory was installed (now there are six such instruments in operation there). During recent years Prof. Schmitt has been working on the isolation of various protein molecules, using especially the giant nerve fibre of the squid. He is at present making studies of collagen in connexion with rheumatoid arthritis and the tanning of leather.

Physics at Newcastle : Prof. W. E. Curtis, F.R.S.

THE recent retirement of Prof. W. E. Curtis from the chair of physics at King's College (University of Dunham), Newcastle upon Tyne, marks the end of a thirty-year period of considerable expansion in the Department of Physics of which he has been director. After holding the posts of lecturer in the University of Sheffield and reader in King's College, London, he went to Newcastle, to what was then Armstrong College, in 1926, as successor to Prof. Henry Stroud. He at once set himself to organize research in the Department and soon had a school of students working in his own subject of spectroscopy, to which later other branches of research were added. The teaching staff on his arrival consisted of four lecturers, a number which has been more than doubled in the ensuing years, while a reader and a professor of theoretical physics have been added to the staff. Beside directing the Department, Prof. Curtis has taken an important part in the administration of the College, being for several years sub-rector. Throughout the First World War he served in the Royal Navy, and during the Second he was in the Ministry of Home Security and then in the Armament Research Department, being superintendent of applied explosives during 1943–45. His work in spectroscopy was recognized by his election to the Royal Society in 1934, and during 1950–52 he was president of the Institute of Physics. Though he has now retired from his chair, Prof. Curtis still has a number of scientific activities, and he is at present remaining in Newcastle.

Royal Society Antarctic Expedition

THE advance party of the Royal Society International Geophysical Year Antarctic Expedition will leave Southampton on November 22 in the M.V. *Tottan* (540 tons) and will prepare the installation of a scientific research station on the Antarctic mainland, on the shores of the Weddell Sea, south of the Falkland Islands. Conditions permitting, it is hoped to set up the station in the Vahsel Bay region (78° S., 35° W.), which is one of great scientific interest for geophysical studies, and, if successful, a further party, eighteen strong, consisting mainly of scientific research workers, will sail in a year's time to relieve the advance party and complete the Royal Society's Antarctic station for the International Geophysical Year (July 1957–December 1958). The station will be one of twenty-two international geophysical stations being set up on the Antarctic mainland by British Commonwealth countries, the United States, the U.S.S.R. and other countries. The advance party will be under the command of Surgeon Lieut.-Commander D. Dalgliesh and will consist of three scientific workers—an electronic engineer from the Army, a radio-astronomer from Jodrell Bank (University of Manchester) and a meteorologist from the Meteorological Office—and six others. The pilot programme of scientific observations includes surface meteorological measurements, ionospheric research, auroral studies, measurements of atmospheric ozone and glaciological observations ; among the scientific instruments will be an all-sky camera which will photograph the aurora australis. The chartering of the ship and the provision of all supplies has been done by the Falkland Islands Dependencies Survey acting through the Crown Agents, on behalf of the Royal Society. The Royal Society has been associated with Arctic and Antarctic expeditions for nearly two centuries : in 1772, in association with the Admiralty, it instructed Captain Cook to "explore the high southern latitudes with a view to determining the existence of a great antarctic continent".

B.B.C. Colour Television Experiments

FOR some time past, the B.B.C. Research Department has been studying the technique of colour television, and recently a programme of experimental transmissions was started outside normal broadcasting hours. On October 20, Sir Harold Bishop, director of technical services, presented a special demonstration for the Press. This comprised the transmission over a closed circuit at the Alexandra Palace station, of still pictures, a short travel film and a number of 'live' camera shots, all of which were reproduced at the receiving end as attractive colour pictures. The technique used in this work is based on the American N.T.S.C. (National Television System Committee) adapted to the British 405-line definition and the normal bandwidth of black-and-white television in Britain. In this system, the red, green and blue components of a coloured picture are 'combined' into a pair of 'chrominance' signals, and a brightness or 'luminance' signal. The latter (luminance) signal can be made to give a compatible picture to a viewer possessing a black-and-white receiver ; and the most important purpose of the present series of experimental transmissions is to determine whether this compatible reception—of a black-and-white picture from colour transmissions—is satisfactory. Viewers participating in these experiments are asked to report on any differences experienced in the sound and vision reproduction as compared with the normal reception of the regular black-and-white programmes. Sir Harold Bishop said that the results of these tests would be reported to the Postmaster General's Television Advisory Committee ; but he thought it unlikely that a colour television service for Britain would be ready for at least three years.

British Museum (Natural History)

THE British Museum (Natural History) has purchased a new specimen of *Scelidosaurus*, a genus which is geologically the oldest armoured dinosaur. Up till now it has been known by one almost complete but somewhat distorted skeleton, already in the Museum, collected and prepared by James Harrison a century ago, and by a few isolated bones of a young *Scelidosaurus* more recently preserved in the Lyme Regis Museum. The latest acquisition was found about a year ago by Mr. J. F. Jackson, of Charmouth, a well-known collector of fossils. He discovered a large slab of Lower Liassic limestone which, on splitting, showed the bones of the hind leg, the hip

girdle, and some of the backbone; there are also indications of the young stages of the bony plates of the back.

During the past few months the Department of Entomology of the Museum has been searching along the south coast of England from Kent to the Isle of Wight for two moths, *Hydraecia hucherardi* and *Lithophane lapidea*. Apart from their rarity, the interest of these two species, which are inhabitants of central and southern Europe, is in the further evidence their occurrence in southern England provides of the gradual change of the climate of the British Isles, a change which is already well supported by botanical evidence. Many specimens of *H. hucherardi*, the larva of which burrows in the roots of the marsh mallow, have been obtained, and the principal features of its life history have been ascertained; very few *L. lapidea* have so far been collected. Other recent work of the Museum includes a collecting trip to Yugoslavia by Mr. R. L. Coe, in order to obtain Diptera, more than nine thousand specimens being collected, during which contacts were made with the staffs of various scientific institutions. Another member of the staff, Mr. P. N. Lawrence, visited the south of France, where he collected more than four thousand specimens of Collembola in the neighbourhood of the Eastern Pyrenees. A very fine series of hydroid medusæ from Plymouth and elsewhere, numbering about fifteen hundred specimens, has been presented to the Museum by Mr. F. S. Russell, director of the Marine Biological Association of the United Kingdom, Plymouth, and a collection of approximately a thousand slides of foraminifera from various horizons from the Cretaceous to Recent has been presented by Miss M. A. Waller.

The Ishihara Test and Defects in Colour Vision

An interesting article by Mr. Peter Cavanagh on "The Ishihara Test and Defects in Colour Vision" has been published in *Occupational Psychology* (**29**, 1; 1955). The investigation was originally undertaken for the guidance of psychologists working in the Industrial Rehabilitation Units of the Ministry of Labour and National Service during the Second World War, and the Ministry has suggested that it should be given wider circulation. It is true that many people with defective colour vision are unaware of their condition, since they see all the things that other people see and they know what colours these things are said to have. This may be fairly adequate for ordinary life; but in certain critical situations they can run into difficulties and even danger, so that it is important that people should be tested for the accuracy of their colour vision. As with all tests concerning human beings, infallibility cannot be claimed; but, used with adequate controls, the test has proved to be of great value. Mr. Cavanagh discusses the incidence and types of defective colour vision, its congenital nature, as well as its occupational implications, with a detailed study of the test, its limitations and value and the technique for reducing error.

Council for the Preservation of Rural England: Report for 1954–55

The twenty-ninth annual report, for 1954–55, of the Council for the Preservation of Rural England (pp. 30; London, 1955) is again a fully documented account of the action taken during the year to safeguard the amenities of rural England. On town and country planning, the Council welcomed the statement of the Minister of Housing and Local Government expressing determination to stop further unrestricted sprawl of the great cities, but regrets the fact that, apart from London, no other great city has defined a formal 'Green Belt' around it. Among other matters to which the Council has given its attention are the control of unsightly advertisements, the location of a number of mineral-working sites, the position of television stations and the distribution of electricity undertakings, the conservation of Nature, the landscape treatment of roads and bridges, pollution of the air, sea and rivers, and the preservation of buildings. In a separate report published by the Sheffield and Peak District Branch of the Council (pp. 30; Sheffield, 1955), an account is given of the vigorous opposition being made to the proposed road-racing circuit in the Peak National Park. Such a circuit was approved in principle by Derbyshire County Council on May 4 without consulting the Peak Park Planning Board; this one-sided action is possible because highway authorities are not subject to planning control.

Association of Applied Biologists: Jubilee Volume

In September last year the Association of Applied Biologists celebrated its fiftieth anniversary by a five-day session in which many distinguished biologists took part and many interesting papers were communicated. The proceedings of the jubilee meeting have now been published as Vol. 42 of the *Annals of Applied Biology* (pp. 414+8 plates. Cambridge: University Press, 1955; 25*s*. net). In all, some thirty-nine speeches and papers are recorded. Some of these deal with general topics such as the changing problems of applied biology, contributed by Sir John Russell, progress in plant pathology by E. C. Stakman, and the contribution of pure science to applied biology by V. B. Wigglesworth. The others relate to a variety of special topics, including the pests of crop plants and of stored products, nematodes, virus and other diseases, the use of growth-regulating substances, education and extension services, crop protection, and the forecasting and assessment of plant diseases. Detailed references to individual papers cannot be made here, but the jubilee volume may unreservedly be recommended to readers in this field as one of exceptional interest and importance.

Sheffield Interchange Organization: Work during 1954–55

At the twenty-second annual general meeting of the Sheffield Interchange Organization, held at the Central Library, Sheffield, another firm was admitted to the Organization, bringing the total membership to forty-one, including the University, the City Library, and industrial and government research institutions. 2,649 books, periodicals and other scientific and technical papers were exchanged during 1954–55. Among the matters under consideration were the difficulties experienced by members in obtaining United States government research reports within a reasonable time, and problems encountered in tracing and consulting university dissertations which might be of interest to industrial research workers. The City Librarian was asked to approach the appropriate authorities regarding the quicker supply of American reports, and he reported correspondence with the Standing Conference of National

and University Libraries, which is attempting to standardize practice and remove some of the restrictions on the freer use of theses. It was agreed that all applications for this material should be made through the City Libraries in future. It was reported that the use made of the deposit collections of British, Canadian and American atomic energy reports in the Sheffield City Science and Commerce Library is increasing. These may be borrowed by any research worker or organization in the United Kingdom, and many have been lent in this way; but an increased number have been asked for by firms in the South Yorkshire industrial area served by the City Science and Commerce Library.

Photometric Studies of a Lunar Eclipse

A PAPER in *Publications de L'Observatoire de Genève* (Sér. *A*, Fasc. 51; 1955) on "Observation of the Total Eclipse of the Moon on January 18–19, 1954", by M. Golay, deals with the results, obtained at the Observatory of Geneva, of the lunar eclipse of January 1954. The observations were carried out with the Schaer refractor, 20 cm. aperture, and were specially directed to a photometric study around 5750 A. This region was selected because Barbier and his collaborators had suggested many years ago that the region 5750–6000 A. should be specially studied, and four photographs were taken in the band 5600–6100 A., each with an exposure of 4 min. From the results a few deductions are made, some of which will be published later. It seems that certain rays may have travelled through a considerable depth of ozone; in addition, certain discontinuities referred to are in accordance with Danjon's law on solar cycles, and it is very probable that 1954 will prove to be the minimum of solar activity.

Welsh Folk Museum, St. Fagans: New Handbook

SUCH is the speed of development of the Welsh Folk Museum at St. Fagans that a new edition of the handbook is welcome (pp. 29. Cardiff: National Museum of Wales, 1955; 1*s*.). The attractive format is similar to that in previous issues, though visitors and others will appreciate descriptions of the recently re-erected Stryt Lydan barn, the Esgair Moel woollen factory, the Abernodvydd and Kennixton farmhouses. It is interesting to note that three other buildings, including a Unitarian chapel dated 1777, have been accepted for re-erection. A part of the much-needed Museum block is now under construction.

Washing of Treated Bronzes

IN the August issue of the *Museums Journal*, Mr. R. M. Organ, of the Research Laboratory of the British Museum, discusses the difficulties encountered in washing treated bronzes. These are shown to be due to the presence of corrosive agents in the untreated objects and to the effects of the reagents usually employed. Practical methods of washing and for controlling the process by measuring electrical conductivity are described.

The Night Sky in November

NEW moon occurs on Nov. 14d. 12h. 01m., U.T., and full moon on Nov. 29d. 16h. 50m. The following conjunctions with the Moon take place: Nov. 8d. 05h., Jupiter 6° N.; Nov. 12d. 01h., Mars 6° N.; Nov. 16d. 07h., Venus 0·2° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Spica on Nov. 2d. 11h., Mercury 4·5° N.; Jupiter with Regulus on Nov. 8d. 13h., Jupiter 0·3° N.; Venus with Antares on Nov. 12d. 22h., Venus 4·1° N.; and Mars with Spica on Nov. 16d. 18h., Mars 3·2° S. Mercury rises at 5h. 10m. on November 1, which is nearly 1¼ hr. before sunrise, and may be seen for a short time in the eastern sky, stellar magnitude 0·7. Its proximity to Spica on November 2 has already been referred to. About the middle of the month, it rises an hour before sunrise and will not be easily observed; after this it draws closer to the sun, reaching superior conjunction early in December. Venus sets at about 17h. 10m. during November; its stellar magnitude remains −3·3, and the visible portion of its illuminated disk varies from 0·963 to 0·924. This decrease is just balanced by its decreased distance from the earth—from 152 to 142 million miles—in consequence of which its stellar magnitude remains unaltered. Mars rises about 4h. 20m. throughout the month. About November 9 it is a little south of θ Virginis, and its easterly movement takes it near κ Virginis at the end of the month. Its stellar magnitude varies from 2 to 1·9 owing to its distance from the earth decreasing from 232 to 216 million miles. Jupiter rises at 0h. 15m., 23h. 30m. and 22h. 40m. on November 1, 15 and 30, respectively. Its close approach on November 8 to α Leonis, which is about two magnitudes fainter than Jupiter, has been pointed out. Saturn, in conjunction on November 16, is too close to the Sun for favourable observation during the month. The Andromedid meteors appear towards the end of November, but this shower is much less prolific than it was in previous years; owing to strong moonlight, they will not be visible this year. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Nov. 9d. 03h. 23·5m., 55 Leo (*R*); Nov. 24d. 22h. 23·3m., 19 Psc. (*D*); *R* and *D* referring to reappearance and disappearance, respectively.

Announcements

DR. J. S. CARTER, deputy chief inspector of alkali, etc., works, has been appointed chief inspector in succession to Mr. W. A. Damon, who is retiring; Mr. Damon will continue with the Ministry in an advisory capacity.

THE second World Congress on Fertility and Sterility, sponsored by the International Fertility Association, will be held in Naples during May 18–26, 1956 and will consist of twelve separate sections dealing with various topics, one of which will be on veterinary problems in animal reproduction. A general lecture will be given at the Congress by Prof. Nils Lagerlöf, of the Royal Veterinary School, Stockholm, on "Biological Aspects of Male Infertility". Those wishing to read papers must send in typed summaries by November 30 and full copies by January 31. All correspondence should be addressed to Prof. Edmundo G. Murray, Ayacucho 1375, Buenos Ayres, Argentina.

MESSRS. EDWARDS HIGH VACUUM (London), Ltd., have recently re-designed their model of the cold-cathode type of electron diffraction camera based on Prof. G. I. Finch's original design. Leaflet *E*.156/1 gives full details of the new model, which incorporates the latest vacuum valves, unions and fittings and pumping equipment, together with information concerning the electron diffraction technique and its applications.

MARINE ORGANISMS AND BIOGEOCHEMISTRY

At the Bristol meeting of the British Association, a joint session between Sections D (Zoology), B (Chemistry) and C (Geology) was devoted to papers on the topic of "Marine Organisms and Biogeochemistry". Dr. C. F. A. Pantin, who was in the chair, stressed the value of joint meetings. It is in these borderline fields, he said, that many complex and interesting problems are found, which for a variety of reasons are generally more difficult to solve than those of the traditional scientific disciplines.

The first paper, by Dr. J. D. H. Wiseman, of the British Museum (Natural History), was on the rates of accumulation of nitrogen and calcium carbonate on the equatorial Atlantic floor. The rate of accumulation of nitrogen is, under ideal conditions, a measure of biological activity, and similarly the rate of accumulation of calcium carbonate is a measure of the productivity of those organisms which secrete calcium carbonate, provided there has been no solution subsequent to deposition. Dr. Wiseman said that geochemically it is significant to determine these rates, and to discover whether a change can be correlated with an alteration in some fundamental property in the upper layer of the sea. The investigation has been carried out on sixty sections each approximately ½ cm. thick. These were taken continuously down an equatorial Atlantic core, collected by the Swedish Deep-sea Expedition of 1947–48. Sedimentation in this core had apparently been continuous, and there was no evidence of disturbance by benthonic organisms, or through other causes.

In order to compute, from the percentages of nitrogen and calcium carbonate, rates of accumulation, it was necessary to determine the weight of dried salt-free sediment in a column of unit area through each section in its original moist condition (hereafter called weight of sediment in the section), as well as the number of years (the age) required to deposit each section. The weight of sediment in a section of known thickness can be computed from its chlorinity. The reason for this is because in highly calcareous deep-sea sediments, composed for the most part of planktonic foraminifera and a clay component, there is a relation between the weight of salt-free sediment in 1 c.c. of the moist sediment and its salt content. Age computations are, therefore, made from the weight in each section of selected elements, the rates of sedimentation of which have been shown to remain constant with time. Dr. Wiseman said that to understand the method it is necessary to appreciate the origin of the non-biological components of deep-sea sediments. The components may be divided into two classes: the hydrogenous components, and the unweathered high-temperature minerals derived from the lithosphere. Included in the hydrogenous components are the secondary minerals formed by ionic reactions in the continental hydrosphere. There are also substances precipitated in the marine hydrosphere—for example, as hydroxides—and some probably in the form of alumino-silicate sols. In addition, there are elements chemically scavenged from sea water. The high-temperature lithogenous minerals are derived from the land, as well as from submarine rocks and volcanoes. Minerals from this source are fortunately very rare in this core.

If the rate of sedimentation of any one of the components of either class changed, this would in general be reflected in a change of chemical composition. For example, if there were a sudden addition of the lithogenous mineral ilmenite, this would be shown by a change in the titanium percentage when expressed on a carbonate-free basis, as well as in the iron/titanium ratio. Dr. Wiseman then gave the theoretical reasons for constancy in the rate of sedimentation of the hydrogenous components in those areas of the deep-sea floor where there had been no superimposed complications. Changes in the rate of sedimentation of the non-biological components were found in terrigenous sediments (derived largely from the land), and in some deep-sea sediments, especially those from volcanic regions, or where there had been sediment transportation by turbidity currents. It was therefore essential, before computing age, to check from the chemical composition of each section that the rates of accumulation of the selected elements had remained constant with time, and that there had been no post-depositional chemical movement.

The percentages of iron and titanium, expressed on a carbonate-free basis, as well as the iron/titanium ratios, showed in this core no appreciable variations. From this it was concluded that there were no significant changes in the rates of accumulation or post-depositional movement of these two elements. The age of each section was computed from the iron and titanium percentages, and where there were notable percentage differences between the two results (the greatest was 12 per cent), it was possible to make an objective choice.

A graph of the rates of accumulation of calcium carbonate for each section shows that the annual rate varies between 0·9 and 1·1 mgm./cm.² during the past 7,000 years; then there is a rapid fall, and at approximately 15000 B.C. the rate is 0·28 mgm./cm.². Similarly, the annual rate of accumulation of nitrogen varies between $2{\cdot}4$ and $3{\cdot}6 \times 10^{-4}$ mgm./cm.² during the past 7,000 years, followed by a rapid fall to $1{\cdot}1 \times 10^{-4}$ mgm./cm.² at approximately 16000 B.C.

Biological examination has demonstrated that when the foraminiferal assemblage was of a warmer type, the rates of accumulation of both calcium carbonate and nitrogen were higher. This conclusion is strongly supported by the temperatures (Table 1) at which the shells of planktonic foraminifera were deposited. These temperatures are based on oxygen-18 measurements, carried out by Dr. C. Emiliani.

Dr. Wiseman concluded that, in the equatorial Atlantic Ocean about 15000 B.C., when the upper layer of the sea was about 5 deg. C. cooler, the rates of accumulation of both nitrogen and calcium carbonate were approximately a third of their present-day values.

The second paper, by Mr. M. V. Strong, of the British Petroleum Research Station, was on iron bacteria as rock-forming organisms. Mr. Strong said

Table 1

Section No.	*P*3	*P*46	*P*48
Globigerinoides sacculifera	24·3° C.	21·2° C.	20·1° C.
Pulleniatina obliquiloculata	21·0	17·9	17·1
Globigerina dubia	19·7	15·0	13·6
Globorotalia menardii	18·7	16·8	—
Globorotalia tumida	15·3	13·6	13·8
Annual rate of accumulation of calcium carbonate	1·00 mgm./cm.²	0·46 mgm./cm.²	0·34 mgm./cm.²
Date of mid-point of section	A.D. 1200	11750 B.C.	12800 B.C.

that the object of his paper was to bring to the attention of microbiologists organic remains, apparently bacterial, preserved in Permian rock salts. Most of the material investigated is from a deep bore-hole at Eskdale. Some of the forms described by Mr. Strong are identical with those in lower Palæozoic rock salts of Saskatchewan. It is of considerable interest that this organic material has so far been found only in red rock salts, in which the iron is present in minute hæmatite crystals, or possibly goethite.

The organisms occur as bright red discrete aggregates, which float upwards on dissolving the salt; the most common forms being needles up to ½ mm. in length. They may be sinuous or straight, and are apparently without branches; the threads may form a network, or may be set in a fine membrane of yellowish material. Rarely the threads show a swollen termination, either cylindrical or spindle-shaped with a grooved point. They are highly resistant to heat and acids, and no internal structure has been seen.

Another common form includes fragments of membranous tissue, sometimes apparently structureless, and at other times enclosing a close mesh of threads. A third form is a cyst-like, lozenge-shaped sac of permeable membrane, enclosing liquid. The length is ½–1 mm. and the width slightly smaller. Twisted threads recalling *Gallionella* occur in the form of ribbons. Mr. Strong suggested that the deposits of hæmatite found on certain islands in the Persian Gulf may be due to the solution of salt plugs in sea water.

The third paper, on the biogeochemistry of strontium, was by Dr. H. J. H. Bowen, of the Atomic Energy Research Establishment, Harwell. Since the advent of nuclear fission, there has been considerable interest in the biological fate of strontium, as two of its isotopes are among the longer-lived fission products of uranium-235. In particular, strontium-90 constitutes the major hazard, since its half-life is approximately twenty years. The element is readily taken up by plants, and in consequence may be concentrated in the bones of animals feeding on contaminated fodder. Although strontium is widely distributed in Nature, little is known about its behaviour in living organisms, apart from the fact that it tends to follow calcium. Limited knowledge about the biological behaviour of strontium is due in part to the lack of sufficiently sensitive analytical techniques for determining small amounts of the element, as well as to chemical interference of calcium, which in biological material is always present in large amounts. Spectrometric determinations are never very precise, and can seldom determine less than 10^{-5} gm./ml. of the element. The method of activation analysis, developed at Harwell, is sufficiently precise to determine 10^{-9} gm./ml. of strontium and is a major advance in the study of the inactive element. The method is used for investigating the occurrence of strontium in rocks, plants, marine organisms and sea water.

In view of the similarity of strontium to calcium, the calcium/strontium ratio is a better index of concentration by an organism than its absolute content. For example, the ratio is 50/1 in sea water, whereas in marine algae (*Laminaria*) it is about 10/1, and in molluscan shells about 200/1. Dr. Bowen concluded from these figures that *Laminaria* prefer strontium to calcium by a factor of five, whereas molluscs reject strontium from their shells by a factor of four. The calcium/strontium ratio in sea water is remarkably small compared with the ratio in most igneous and sedimentary rocks, where it ranges from 100/1 to 1,000/1. Strontium is, therefore, an element which accumulates in the sea, whereas calcium is removed by marine organisms and, to a small extent, by chemical precipitation.

In contrast to its behaviour in marine algae, strontium is neither rejected nor accumulated by the majority of land plants. The calcium/strontium ratio in the plant is generally similar to the available ratio in the soil on which the plant grows. However, in the Bristol district, where there are deposits of celestine, the strontium content of the soil is very high, and plants from this soil reject strontium in favour of calcium. In the Avon Gorge, a locality rich in strontium, one of the rare plants, the Bristol rock cress (*Arabis stricta*), may accumulate strontium. Further work is, however, required, because the low calcium/strontium ratio may in part be due to strontium contamination on its leaves.

J. D. H. WISEMAN

SURFACE RHEOLOGY

ANNUAL CONFERENCE OF THE BRITISH SOCIETY OF RHEOLOGY

THE annual conference of the British Society of Rheology was held in the Washington Singer Laboratories of the University College of the South West, Exeter, during September 22–24. Dr. S. Gregg (University College, Exeter) opened the conference with a paper on the effect of adsorption on the strength of brittle solids. After summarizing the general theory of the subject, he described his recent experimental work, assisted by Dr. D. Dollimore and Dr. A. Desai, on the strength of compacted disks of compressed powders, broken *in vacuo* and in controlled atmospheres. Adsorption isotherms were prepared. The density of elastic energy located between two planes at distance a apart is $\frac{1}{2} \cdot \frac{\sigma^2}{E} \cdot a$, where σ is the stress and E Young's modulus. Although, in the case of glass at the rupture point the value of $\sigma_{max.}$ is calculated to be 10^{11} dyne cm.$^{-2}$, the experimentally measured value is about one-hundredth of this amount. The discrepancy is attributable to the weakening effect of the adsorption of water molecules on the surfaces of incipient cracks. The reduction in surface energy on exposure to vapour, ($\gamma_{vac.} - \gamma_{vap.}$), in relation to the amount

adsorbed per gm. of solid is $\frac{RT}{SM}\int_0^p x \, d \ln p$, where S is the specific surface, p the pressure of adsorption and M the molecular weight. Graphs relating the breaking strength of disks of compacted calcium carbonate, kaolin and boric acid powders, measured under different states of adsorption and desorption, together with derived graphs relating strength and surface energy, etc., were shown.

When benzene vapour replaced that of water in the experiments the strength of the disks remained practically unchanged, although the vapour had been strongly adsorbed with a consequent fall in surface energy. Dr. Gregg explained this anomaly as being due to the relatively large size of the benzene molecule, the ingress of the vapour into the cracks being prevented. In the discussion the meeting supported this view, and considered explanations of other anomalies found under conditions of supersaturation, and the partial absence of hysteresis with boric acid during adsorption and desorption.

In a paper on lubrication by films of solid materials, Miss E. Kay spoke on an investigation at the Royal Aircraft Establishment, Farnborough, made jointly with Mrs. E. Bielak and Dr. E. W. J. Mardles, in which a wide variety of fine powders, including metallic stearates, waxes, polytetrafluoroethylene, molybdenum sulphide, graphite, etc., dry and dispersed in liquid media, were examined under different conditions and between various bearing surfaces. Dry lubrication is often preferable both under the condition of a wide temperature-range, such as that with aircraft, −80° C. to beyond 250° C., and with light mechanisms of precision when oil seepage and creep, even of 'non-spread' oils and with use of 'epilame' barriers, tend to produce dry bearings and alteration in the inertia of fine moving parts. It was found that with a dry lubricant, although a higher coefficient of friction may be obtainable, the coefficient changes but little over a wide temperature-range. A wide scatter of results obtained with powders under some conditions is attributed to the inclusion of moisture or of oil, to failure of the surface to retain the solid lubricant and to physical changes. Considerable attention is required to find the best method of applying solids for different lubricating purposes.

Members of the meeting then discussed the effect of particle size and shape and the relative merits of dry powders and their use in oil and grease dispersions.

A. F. Latham with Dr. K. G. A. Pankhurst (British Leather Manufacturers Research Association, Egham) spoke on surface viscometry—the tanning of protein monolayers. Insoluble monolayers, spread on a water surface, may exist in a variety of states of aggregation ranging from a rigid two-dimensional 'solid' to an almost perfect surface 'gas'. Mr. Latham described the design and use of a rotational viscometer for measuring the viscous drag of these surface films and distinguishing between Newtonian and non-Newtonian flow.

Protein monolayers exhibit a wide variety of surface rheological properties according to the surface pressure. The changes are reversible and, in the case of serum albumen, can be interpreted by change from the α- to β-keratin pattern. The surface viscosity of collagen is much lower than that of serum albumen due to reduced inter-chain linkage; but, when spread on a tanning material such as mimosa tannin, the surface viscosity increases by nearly a thousandfold. Mr. Latham described how use is made of the rate of formation of cross-linking to investigate tanning reactions. In reply to queries, he spoke on results obtained with a number of substrates and on the technique used for examining various rheological properties of the monolayers.

In a paper on surface films of poly-di-methyl siloxanes on organic liquid substrates, Dr. W. H. Banks (Printing, Packaging and Allied Trades Research Association, Leatherhead) considered the spreading behaviour of a silicone fluid of average molecular weight 2,000, its surface films having the property of suppressing the foaming of oils and the mottling of paints. The special apparatus developed for the study was described, and graphs were shown relating results obtained for film pressure and film area. Hysteresis effects were observed. Lycopodium was used for observing the rate of spreading on a variety of organic liquids, which was found to be in accord with the relation $l \propto \sqrt{t/\eta}$, l being distance moved, t time in sec. and η the viscosity of the substrate. The movement of the surface films caused a gradient in the substrate, a film of thickness 25 A. being sufficient to cause motion. In the discussion that followed, members considered possible mechanisms of action of silicone fluid films in suppressing foaming, mottling, evaporation and surface turbulence.

In their paper on the rheological properties of dispersions as criteria of the degree of wetting, Dr. E. W. J. Mardles (Farnborough) and Mr. A. de Waele (Gestetner, Ltd.) first pointed out the difficulties of ascertaining the degree of wetting of a solid surface by a liquid using the Young–Dupré equation modified by Harkins. Contact angles at 'equilibrium' may not exist due to the presence of adsorbed liquid films beyond the periphery of the pool, and the spreading of a liquid over a solid surface can be shown to be non-Newtonian. Although there is some correlation between heats of immersion of powders in various liquids and the rheological properties of their dispersions, numerous exceptions occur due possibly to the fact that the wetting of a surface by a liquid continues over a long period of time. Evidence of this is given by a decrease with time in the viscosity of a freshly made dispersion, by the decrease in the coefficient of friction by oil between bearings during several hours of wetting, and by electrical conductivity measurements which, in the case of a dispersion of carbon black in liquid paraffin (British Pharmacopœia), continued to change over a period of twelve months. The authors presented results in graphical form indicating the effect of adding wetting-agents on the rheological properties and conductivity of a number of suspensions. Using one powder dispersed in a variety of liquids, or several different powders dispersed singly in the same liquid, the concentration by volume being the same, the rate of aggregation of the particles (indicated by the rheological constants, by the sedimentation-rate and volume, and by conductivity tests) was found to vary considerably, the variations being related to the degree of wetting of the particles by the dispersing media.

The conference included an afternoon visit to the works of the Exeter Brick and Tile Co., Ltd., when Dr. H. H. Macey gave a talk on rheological problems connected with clays and ceramics. At the annual general meeting of the Society, Prof. J. G. Oldroyd was elected president.

E. W. J. Mardles

INDUSTRY AND TECHNICAL EDUCATION IN GREAT BRITAIN

A CONFERENCE on "Industry and Technical Education", organized by the Regional Advisory Council for the Organization of Further Education in the East Midlands and by the North Midland Regional Council of the Federation of British Industries, was held at the College of Technology, Loughborough, on April 21, 1955, and the report of the conference has now been published*. It contains the text of the chief addresses and summaries of the discussions at the two sessions.

At the first of these sessions, which considered the relation between part-time, full-time and sandwich courses, Dr. H. L. Haslegrave, putting the point of view of the technical college, expressed the opinion that the technical college is concerned with the development of the whole man, his character and his mind, and that the best training in the application of knowledge is to use it by actually doing things. He emphasized the importance of technical colleges, as well as industry, making full use of their personnel even if it involves a policy of concentration of courses. He thought that the field for full-time courses of three to five years is restricted to branches of industry in which extensive practical training is unnecessary or in which facilities for such practical training do not yet exist. Courses for semi-skilled and skilled personnel, for technicians and for professional men should be regarded as of equal importance. Putting the point of view of the engineering industry, Air Commodore W. C. Cooper said that for the professional engineer or technologist a full appreciation of the economic factors is as essential as high standards of technical competence and knowledge. He thought, however, that there is a danger of overstressing the need for such men and women, because in the main the new knowledge must come from those who have received the equivalent of a full-time university education of at least three years, and he questioned the desirability of employing those so trained in technological applications. He did not think that the sandwich course is the ideal form of training for technical staffs, preferring an industrially based residual training in industrial colleges specifically created for the purpose.

Mr. R. B. Simpson, speaking for the textile industry, thought that, for persons fifteen years old leaving secondary modern schools, technical colleges provide the opportunities and encouragement to obtain the qualifications which employers can recognize as an accepted standard of achievement in their particular sections of the textile industry. The technical colleges also have to cater for grammar-school boys, particularly those who have failed to achieve the necessary subjects at the Ordinary level of the General Certificate of Education to enable them to go forward to a degree. For graduates, they provide the courses, possibly a sandwich course, leading to an associateship of the Textile Institute. The discussion also emphasized the importance of developing loyalties in young people, by showing them how their work helps both their companies and contributes to the welfare of the whole community, and the value of those who are technically qualified and possess the ability to get the best out of their workpeople.

The second session was concerned with the promotion of increased co-operation between industry and technical education. Mr. R. E. Wood dealt with the functions of the governing body and advisory committees of a technical college, and stressed particularly the value of part-time staff from industry. Mr. F. Stephenson, dealing with the work of local education authorities in this field, thought that the Regional Advisory Council is the most effective means for promoting increased co-operation; but he also stressed the value of adequate grants to students and of major awards for full-time students at technical colleges. Mr. J. C. McMeeking, reviewing the existing machinery for promoting co-operation, thought that, though it goes a long way towards meeting the needs, it could be improved by giving more attention to the needs of small firms and by making craft training in colleges more practical. Every effort should be made to release more teachers for periods in industry, and it is desirable to include more members from industry on governing bodies as well as to obtain the active interest of the foremen and middle-management. Conferences of technical teachers and industrialists (including foremen) would be of mutual benefit.

* Report of the Conference on Industry and Technical Education. (Organized by the Regional Advisory Council for the Organization of Further Education in the East Midlands and the F.B.I. North Midland Regional Council, and held at the College of Technology, Loughborough, 21 April 1955.) Pp. iii+41. (London: Federation of British Industries, 1955.) 4s.

ENGINEERING AND PURE SCIENCE

FOR the twenty-third Andrew Laing Lecture which he delivered on December 10, 1954, to the North East Coast Institution of Engineers and Shipbuilders, Sir Edward Appleton chose as his subject "The Partnership of Science and Engineering". That there is a natural partnership between science and engineering may be illustrated by innumerable examples, current and historic, and, in developing his theme, Sir Edward selected his illustrations from widely varied fields. His aim was, however, not so much to demonstrate the existence of this partnership as to emphasize its importance under modern conditions.

Making a clear distinction between pure science and engineering based on the principle that the aim of engineering is essentially 'constructional', Sir Edward went on to consider the differences between scientific discovery and invention. A scientific discovery, he pointed out, does not necessarily involve invention, although it will, in general, increase the area of invention, and conversely an invention is not necessarily directly associated with scientific discovery. Speaking of the essential distinctive quality of invention, Sir Edward said that the inventive step must contain more than deductive reasoning. "Indeed," he remarked, "my own view is that the impact of an invention on the minds of others skilled in the art, should engender surprise."

The development of engineering as an art has from its early beginnings stimulated inventions and discoveries which can properly be classed in the field of pure science, and likewise advances in scientific knowledge have been turned to account in the practice of engineering. As a notable example of collaboration between the engineer and the pure scientist, Sir Edward referred to the development of vacuum technique during and subsequent to the First World War. Before the First World War the gas pressure

in electric lamp bulbs was of the order of 10^{-3} mm. of mercury, while at the present day the residual gas pressure in certain valves can be as low as 10^{-9} mm. of mercury. It is largely as a result of these improvements in vacuum technique and their influence on the 'longevity' of thermionic valves that projects such as that of trans-Atlantic telephone cables have become practicable. In the submerged repeaters of the present trans-Atlantic cable, there are some three hundred valves, and the success of the scheme depends upon these valves having lives of the order of twenty years. The development of the thermionic valve has provided the technical basis for the building up of an entirely new subject, namely, that of electronics.

The release, in useful form, of the energy of nuclear fission is, of course, the supremely important new application of physical science in the field of engineering. After describing the basic phenomena of the disruption of the uranium-235 nucleus and mentioning that the first self-sustaining pile generating heat by a nuclear fission chain was set up by Fermi in Chicago in 1942, Sir Edward stated that, in the nuclear energy station at present under construction in Cumberland, the reactor temperature would be maintained at about 400°C. and that carbon dioxide gas under pressure would transfer heat from the uranium-graphite core to steam-raising equipment which would operate electrical generating equipment of normal type. Because of the temperature limitation in the reactor, however, it is unlikely that the overall efficiency of this station will exceed 25 per cent. Sir Edward went on to mention the principles of the 'breeder pile' and the problems associated with it. He then remarked: "You will have seen that the subject is now so far developed that much of the work is out of the hands of the physicist working alone. But I do want to stress that our nuclear engineer will be dealing with problems which, as an engineer—be he civil, mechanical or electrical—he will never have encountered before. Materials will have to take on for him an entirely new meaning." There would be problems associated with materials hitherto unfamiliar in engineering practice, important because of their neutron-absorbing properties, together with exceedingly important metallurgical questions concerned with the development of materials for use at temperatures much higher than those which had been common in the past. "It seems to me," he went on, "that our interest in the nuclear energy field should be one of intense preoccupation. I see, ahead, the development of an enormous industry based on technology—the industry of not only supplying ourselves with nuclear electricity generating stations, but of supplying other countries with them and possibly selling them fissile materials which we have ourselves produced from fertile uranium or thorium."

Remarking that his examples had so far been drawn from the realm of physics and engineering, Sir Edward turned to several instances of the co-operation of the chemist and the engineer. He took first that of the extraction of germanium from flue dust. This metal, which is now of immense importance as a semiconductor for the manufacture of diodes and triodes for the electronics industry, may be present in a proportion of the order of 0·5–1·0 per cent in flue dust. A novel metallurgical treatment has been developed which is much more successful in extracting the metal from certain dusts than the ordinary acid treatment. Sir Edward then mentioned some of the problems associated with the manufacture of titanium and zirconium, the use of sodium benzoate as a corrosion inhibitor and finally, as an example of existing technological development facilitating the work of the pure scientist, the application of the technique of distillation to such laboratory processes as the fractionation of isotopes.

In his concluding remarks, Sir Edward referred to the importance of the development of automatic methods in the manufacturing industry. This is a revolutionary development which will call for statesmanship on the part of both management and labour. He also spoke with approval of the policy of the Atomic Energy Authority in respect of regarding industrial firms as the appropriate bodies to carry out the design as well as the construction of nuclear power plants. He regarded it as essential that nuclear scientific and engineering knowledge should be available to manufacturing firms. The close and effective partnership of science and engineering is, in his opinion, something which is absolutely vital to the economic progress of Great Britain.

NATIONAL PHYSICAL LABORATORY NOTES ON APPLIED SCIENCE

THE latest publications in the series "Notes on Applied Science" of the National Physical Laboratory, Teddington*, illustrate the wide range of investigations undertaken by the Laboratory, since all three are based on actual experience at the Laboratory. No. 10 in the series, "Noise Measurement Techniques", deals with the measurement of noise, defined as "any sound which is undesired by the recipient"; and is intended to act as a guide to the choice of methods and techniques suitable for the measurement of the physical characteristics of noise in varying circumstances. In two introductory sections, the general, physical and subjective characteristics of noise and the principles of broad-band and narrow-band analysis are discussed, and the remainder of the booklet is devoted to a detailed description of noise-measuring equipment, its operation and calibration. Microphones, pre-amplifiers, output meters, recorders and analysers are given full and adequate treatment, and the booklet concludes with a brief, illustrated, account of the Mobile Acoustical Laboratory at Teddington.

The second booklet, No. 11, is concerned with wind effects on bridges and other flexible structures, and is based on wind-tunnel research carried out in the Aerodynamics Division of the Laboratory, where extensive investigations have been made recently on the oscillatory effects of winds on models of two proposed suspension bridges—the Severn Bridge between Beachley and Aust, and the Runcorn–Widnes Bridge over the River Mersey. Most of the booklet is devoted to oscillatory effects although brief reference is made also to static wind loads; while bridges are the primary concern of the booklet, much of the content is also applicable to other flexible structures, such as tall chimney stacks, transmission lines and buildings. It is emphasized that an examination of the history of bridge failures reveals that a bridge

* National Physical Laboratory: Notes on Applied Science. No. 10: Noise Measurement Techniques. Pp. iv+40+3 plates; 2s. net. No. 11: Wind Effects on Bridges and other Flexible Structures. Pp. iv+14+7 plates; 1s. 6d. net. No. 12: Calibration of Temperature-measuring Instruments. Pp. iv+47+2 plates; 2s. net. (London: H.M.S.O., 1955.)

fails because of both static action of wind (that is, a tendency to give the bridge a steady deflexion) and dynamic action (that is, a tendency to set the bridge oscillating), and that, in addition, the dynamic effects can occur in two ways, termed aerodynamic instability and buffeting. The experimental methods to investigate static action, aerodynamic instability, and buffeting on bridges are described in detail and the necessary equipment and the models used at the Laboratory are illustrated.

The third booklet, No. 12, entitled "Calibration of Temperature-Measuring Instruments", refers to a different but important section of the National Physical Laboratory's work, namely, the maintenance of standards, and in this particular case to the basic scales of temperature and the instrumental means by which they are realized. It is the most up-to-date text on the subject, and should receive the widest possible circulation. It sets forth clearly what is meant by a temperature scale, and draws a careful distinction between accuracy and reproducibility in temperature measurement, quoting as an example that the sulphur boiling point, defined as 444·600° C., may be reproduced with the platinum-resistance thermometer to about 0·005 deg. C., but its value by gas-thermometer observation is not known to better than ±0·1 deg. C. The various arrangements for the realization of the primary fixed points, including the triple point of water, and the necessary precautions to be taken, are described in detail, in addition to the primary standard and working standard instruments used at the Laboratory. One section is devoted to a description of the methods used for the routine testing of temperature-measuring instruments, and another to the baths and furnaces used in comparison tests with standard instruments; in an appendix, the definition of the 1948 International Temperature Scale is reproduced.

METABOLISM OF PROPIONIC ACID IN ANIMAL TISSUES

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ANIMAL tissues can oxidize propionic acid; but the mechanism of this oxidation has long remained obscure. Some workers believe that this fatty acid undergoes α-oxidation to yield acrylic, lactic and pyruvic acid[1–3], the latter being oxidized to carbon dioxide and water via the citric acid cycle. However, experiments on the distribution of carbon-14 from labelled propionate in tissue glycogen[4] and acetyl groups[5], or in lactate[6], indicated the occurrence of a symmetrical intermediate between propionate and pyruvate, such as would be formed if propionate or acrylate were first carboxylated to succinate or fumarate, followed by oxidation of the dicarboxylic acid through the citric acid cycle. This possibility appeared to be strengthened by the finding of bacterial enzymes which catalyse the reverse reaction, that is, the decarboxylation of succinate via succinyl coenzyme A, to propionate[7]. More recently, an adenosine triphosphate-dependent conversion of propionate to succinate by fixation of carbon dioxide has, in fact, been reported to occur in liver extracts[8].

Biosynthesis of Methylmalonate

We have found that dialysed extracts and ammonium sulphate fractions of pig heart, supplemented with propionyl coenzyme A, adenosine triphosphate and magnesium ions, fix carbon-14 dioxide to form a compound easily hydrolysed by alkali to yield carboxyl-labelled methylmalonic (*iso*succinic) acid[9]. The latter has been identified by (*a*) paper chromatography and autoradiography, (*b*) recrystallization with carrier, and (*c*) recovery of radioactivity in a derivative, C-methylbarbituric acid, or in propionic acid and carbon dioxide following decomposition at 150°. Under optimal conditions for the synthesis of methylmalonate, no succinate is formed by the pig heart preparations. The conversion of propionate to methylmalonate has been independently observed by Katz and Chaikoff[10] in rat liver slices.

The requirements for methylmalonate synthesis are shown in Table 1. It may also be seen in the table that propionyl coenzyme A can be replaced, although less effectively, by a mixture of propionate and coenzyme A. Under these conditions, propionyl coenzyme A is undoubtedly formed through reaction 1, catalysed by the acetate activating enzyme[11,12], which is also active with propionate.

$$\text{Propionate} + \text{CoA} + \text{ATP} \rightleftharpoons \text{Propionyl CoA} + \text{AMP} + \text{PP} \quad (1)$$

Little or no fixation (or exchange) of carbon-14 dioxide was observed with acrylyl or succinyl coenzyme A in place of propionyl coenzyme A, or with succinate or

Table 1. Requirements for Enzymatic Synthesis of Methylmalonate from Carbon-14 Dioxide and Propionyl Coenzyme A

Components	Carbon-14 dioxide fixed (per cent)*
Complete system†	6·0
" " + coenzyme A	6·0
No enzyme	0
No adenosine triphosphate	0·03
No magnesium chloride	0
No propionyl coenzyme A	0·02
" " " propionate	1·5
" " " methylmalonate	0·1
" " " succinate	0·02
" " " succinyl coenzyme A	0·01

* Results from several experiments.

† Consisting of following components (in μmoles): tris(hydroxymethyl) aminomethane buffer, *p*H 7·0, 50; magnesium chloride, 2; reduced glutathione, 5; adenosine triphosphate, 2; propionyl coenzyme A, 1; potassium bicarbonate-^{14}C, 10; pig heart extract with 5 mgm. protein. Volume, 1·0 ml. Other additions, each 1 μmole except succinyl coenzyme A, 2 μmoles. Coenzyme A added in the last four experiments. Incubation 60 min. at 25°. Heart and other extracts prepared by homogenizing fresh tissue in a Waring blendor with 4 volumes of 0·05 *M* potassium phosphate buffer, *p*H 7·4, containing 0·2 *M* potassium chloride, and centrifuging 15 min. at 25,000 *g*. Supernatant dialysed overnight against 0·02 *M* potassium phosphate buffer, *p*H 7·0, containing 0·001 *M* neutralized L-cysteine. All operations carried out at 3–4°. Fractions obtained from the extracts by precipitation with ammonium sulphate between 30 and 50 per cent saturation, and dialysed as above, have also been used.

* Postdoctoral fellow of the American Heart Association. Most of this work was done while the author was assigned from the Laboratory of Cell Physiology, National Heart Institute, National Institutes of Health, U.S. Public Health Service.

methylmalonate plus coenzyme A in place of propionate and coenzyme A.

The requirement of adenosine triphosphate for the synthesis of methylmalonate from propionyl coenzyme A and carbon dioxide indicates that phosphate bond energy is utilized in this reaction and recalls the results of Bachhawat *et al.*[13] with a possibly analogous reaction, the carboxylation of β-hydroxy*iso*valeryl coenzyme A to β-hydroxy-β-methylglutaryl coenzyme A.

As already mentioned, the immediate product of the adenosine triphosphate-dependent carboxylation of propionyl coenzyme A in pig heart extracts is not free methylmalonic acid but an activated form of this compound. Thus, on addition of hydroxylamine at the end of incubation for an hour of pig heart extract with coenzyme A, adenosine triphosphate, magnesium ions, propionate and carbon-14 dioxide, about 80 per cent of the carbon-14 dioxide fixed in non-volatile compounds can be recovered in the methylmalonmonohydroxamic acid area of paper chromatograms, and 20 per cent in free methylmalonic acid. Control experiments excluded the possibility that free methylmalonic acid is formed first and activated afterwards. Similar results are obtained when hydroxylamine is present throughout the incubation, except that, in this case, there is formation of unlabelled propionhydroxamic acid besides labelled methylmalonmonohydroxamic and methylmalonic acids. Whether or not any diactivated methylmalonate is formed during the incubation cannot yet be stated.

Isomerization of Methylmalonate

In contrast to the pig heart preparations, dialysed extracts of rat heart, liver or kidney, or of sheep kidney, with little or no succinoxidase activity, form both carboxyl-labelled methylmalonic and succinic acids (or labile derivatives thereof) from propionyl coenzyme A and carbon-14 dioxide, in the presence of adenosine triphosphate and magnesium ions. Succinate was identified by paper chromatography followed by autoradiography, and by recrystallization with carrier. It can be readily differentiated from methylmalonate by heating with acid permanganate—a treatment which quantitatively destroys methylmalonate but does not affect succinate.

These results suggested to us the possibility of an enzyme-catalysed interconversion of methylmalonate and succinate, a hypothesis that was quickly shown to be correct by the finding that methylmalonate-1-^{14}C is largely converted to succinate (or a labile derivative thereof) on incubation with the above dialysed liver or kidney (but not pig heart) extracts[9]. In fact, this isomerization is usually the only reaction which methylmalonate can be shown to undergo in the crude extracts. Under some, as yet poorly identified, conditions, 5–10 per cent of the radioactivity of carboxyl-labelled methylmalonate can also be recovered as carbon-14 dioxide, presumably due to a more or less direct decarboxylation, rather than to oxidation of succinate. As shown in Table 2, the conversion of methylmalonate to succinate requires coenzyme A and adenosine triphosphate, and is markedly increased by the presence of magnesium ions. These requirements suggest activation of methylmalonate to methylmalonyl coenzyme A as a preliminary step for isomerization. It should also be noticed (Table 2) that the reaction is inhibited by malonate. Experiments to ascertain whether succinate can be converted to methylmalonate have so far given negative results, but further work will be required to decide whether the primary isomerization reaction is reversible.

Table 2. Requirements for Enzymatic Conversion of ^{14}C-Methylmalonate to Succinate

Components	Carbon-14 appearing as succinate (per cent)
Complete system*	81
No enzyme	0
No adenosine triphosphate	0
No coenzyme A	10
No magnesium chloride	25
Complete system with 0·005 *M* malonate	0

* Consisting of following components (in μmoles): glycine buffer, *p*H 9·0, 100; magnesium chloride, 10; reduced glutathione, 8; adenosine triphosphate, 8; coenzyme A, 1; methylmalonate-1-^{14}C, 0·5; potassium bicarbonate, 10; rat liver extract with 15 mgm. protein. Volume, 1·0 ml. Incubation, 60 min. at 25°.

When carboxyl-labelled methylmalonate is converted enzymatically to labelled succinate, the radioactivity of the latter does not seem to be significantly decreased by the presence of large pools of potassium bicarbonate, propionate or propionyl coenzyme A in the reaction mixture (Table 3)[9]. Since methylmalonic acid might react as an asymmetric compound on enzymatic isomerization, carboxyl-labelled methylmalonic acid was prepared in two different ways by incubation of pig heart extracts, in the presence of coenzyme A, adenosine triphosphate and magnesium ions, either with carbon-14 dioxide and propionate or with carbon dioxide and propionate-1-^{14}C. Both preparations were used, separately, in the experiments of Tables 2 and 3. Similar results with methyl-labelled ^{14}C-methylmalonate (prepared by Dr. H. Castro in this laboratory) provide further evidence that the isomerization reaction involves the conversion of the whole carbon skeleton of methylmalonate to succinate. These results appear to rule out not only a decarboxylation of methylmalonate to carbon dioxide and propionate or propionyl coenzyme A, followed by recarboxylation to succinate, but also the intermediary formation of a carboxymethylmalonate derivative followed by the loss of one of the labelled carboxyls, since both carboxyl groups of methylmalonate are retained in the succinate formed. The elimination of a possible tricarboxylic intermediate is of particular interest, since the formation of such a compound might otherwise account for the apparent stimulation of the isomerization reaction by the bicarbonate ion (HCO_3^-) (Table 3). Purification of the isomerizing enzyme or enzyme system may throw light on the mechanism of this novel reaction, as yet without precedent in biochemistry. It is of interest to note that although methylmalonic acid was isolated twenty years ago from the urine of normal rats by Boyland and Levi[14], and has been found in the urine more recently in other labor-

Table 3. Conversion of ^{14}C-Methylmalonate to Succinate in Presence of Bicarbonate, Propionate and Propionyl Coenzyme A

Additions to complete system*	Carbon-14 appearing as succinate (per cent)
None	75
Potassium bicarbonate (30 μmoles)	100
Potassium bicarbonate (20 μmoles) and propionate (5 μmoles)	97
Propionyl coenzyme A (3 μmoles)	64

* Complete system and incubation as in Table 2, except that only trace amounts of methylmalonate-1-^{14}C were used.

atories[15,16], there had been no other indications that this compound might be a metabolite in the mammalian organism.

As might be expected from the inhibitory effect of malonate on the isomerization reaction (Table 2), in the presence of malonate relatively less succinate and more methylmalonate are formed by liver extracts, from propionyl coenzyme A and carbon-14 dioxide, than in the absence of malonate (Fig. 1). This result suggests that an activated methylmalonate may be an actual intermediate in the conversion of propionate to succinate; but an alternative interpretation, namely, that methylmalonate may be converted to succinate through some common precursor of the two dicarboxylic acids, has not been excluded. The hypothetical common precursor could not, however, be in isotopic equilibrium with carbon dioxide, propionate, or propionyl coenzyme A.

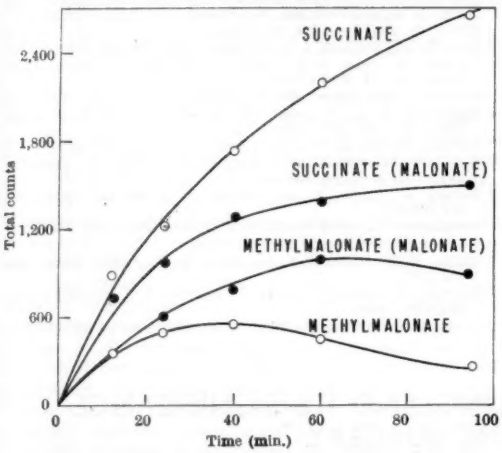


Fig. 1. Formation of methylmalonate and succinate by liver extracts, in the presence of carbon-14 dioxide, propionyl coenzyme A and adenosine triphosphate, and the effect of malonate. One of the reaction mixtures contained (in μmoles), tris(hydroxymethyl)aminomethane buffer, *p*H 7·0, 750; magnesium chloride, 70; reduced glutathione, 50; adenosine triphosphate, 75; propionyl coenzyme A, 3·5; potassium bicarbonate-^{14}C, 70; extract of rat liver acetone powder with 250 mgm. protein. Volume, 11 ml. The other reaction mixture contained 0·01 mole malonate besides the above components. Incubation at 25°

Oxidation of Propionate and Methylmalonate

Experiments with rat liver homogenates (Fig. 2) show that oxidation of propionate is markedly dependent on the presence of bicarbonate ions, whereas that of methylmalonate, although stimulated by bicarbonate ions, is not so dependent. On the other hand, the oxidation of succinate and octanoate by the same preparations is not affected by the presence of bicarbonate ions. The homogenates were prepared as described by Lehninger and Kennedy[17]. Since methylmalonate is oxidized, this compound (or, more likely, an activated derivative) could be an intermediate in propionate oxidation. Stimulation by bicarbonate ions of methylmalonate oxidation may be related to the above-mentioned stimulation of the isomerization reaction. Carbon dioxide-free water as well as carbon dioxide-free solutions of the various reagents were used for the experiments of

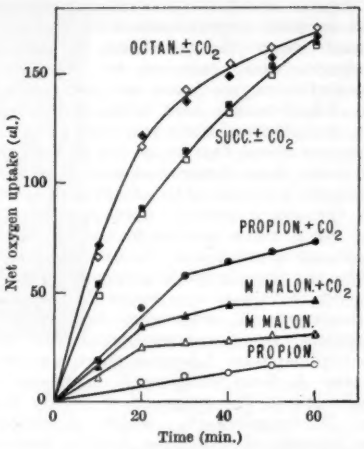
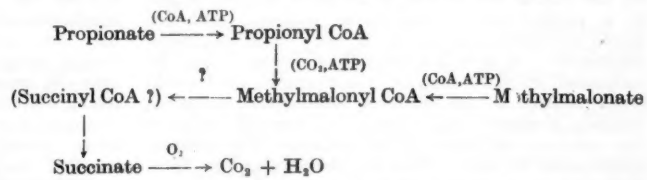


Fig. 2. Oxidation of propionate, methylmalonate, succinate, and octanoate by rat liver homogenates. Each Warburg flask contained (in μmoles), potassium phosphate buffer, *p*H 7·4, 90; potassium chloride, 150; magnesium sulphate, 15; adenosine triphosphate, 3; cytochrome *c*, 0·004; substrate (potassium salts), 3; enzyme suspension, 1·5 ml. Volume, 3·0 ml. Gas, air; temperature, 30°. Alkali-soaked filter paper in centre well. Two flasks were run with each substrate, one containing, in addition to the above components, 20 μmoles potassium bicarbonate, the other 35 μmoles tris(hydroxymethyl)aminomethane buffer, *p*H 8·3. The final *p*H in all flasks was about the same, around *p*H 7·6. The oxygen uptake in the absence of added substrate (about 20 μl. in 60 min. in all cases) was subtracted. Enzyme suspension prepared by homogenizing the livers of 24-hr. fasted rats with 2 vol. of ice-cold 0·013 *M* phosphate buffer, *p*H 7·8, containing 0·013 *M* potassium chloride, in a Potter-Elvehjem homogenizer. The suspension was mixed with an equal volume of the same solution and the mixture centrifuged at 2,200 *g* and 0° for 3 min. The sediment was taken up in a volume of phosphate–potassium chloride equal to that of the diluted homogenate, the mixture centrifuged and the sediment resuspended once more as above

Fig. 2. In addition, the *p*H of the reaction mixtures with no added bicarbonate was adjusted to a value close to the value of those with added bicarbonate, so that the observed results are due to the bicarbonate ion, and not to the effect of increased *p*H.

The above results indicate that, in liver homogenates, propionate is oxidized exclusively through a pathway involving preliminary carboxylation. The same conclusion has recently been reached by Wolfe[16], whose experiments with rabbit liver homogenates clearly exclude α-oxidation of propionate via lactate, and demonstrate its oxidation through succinate. Thus, the conclusions of Huenneckens *et al.*[2] and Mahler and Huenneckens[3] are not borne out by the more recent work.

The pathway of propionate and methylmalonate oxidation in animal tissues suggested by our experimental results is shown by the sequence below:



The fact that the oxidation of methylmalonate is slower than that of propionate (Fig. 2) does not exclude this scheme, since activation must precede oxidation of these compounds and may limit to

different degrees the rates of oxidation of the free acids. In separate experiments with the rat liver homogenates, where the activation of propionate, methylmalonate and octanoate by adenosine triphosphate and coenzyme A was followed through the formation of hydroxamic acid, it was found that the activation of methylmalonate was very slow, that of propionate was about four times faster, and that of octanoate seven times faster than that of propionate. While octanoate is activated by a fatty-acid activating enzyme[19], through a reaction analogous to (1), the nature of the enzyme catalysing the activation of methylmalonate is unknown. Methylmalonate is not activated by the phosphorylating enzyme of Kaufman *et al.*[20], which catalyses the reversible formation of succinyl coenzyme A, adenosine diphosphate and orthophosphate, from succinate, coenzyme A and adenosine triphosphate. Likewise, there is no transfer of coenzyme A from acetoacetyl coenzyme A to methylmalonate in the presence of highly purified coenzyme A transferase[21], which catalyses the reversible transfer of coenzyme A from acetoacetyl coenzyme A to succinate. While the product of carboxylation of propionyl coenzyme A might be methylmalonyl coenzyme A, which could then undergo isomerization, it is not known whether the immediate product of the isomerization reaction is succinyl coenzyme A, some other form of activated succinate, or succinate itself. Furthermore, as already mentioned, the results so far obtained do not exclude a common precursor of both methylmalonate and succinate as the immediate product of the carboxylation reaction. The separation and purification of the enzymes involved may help to decide these questions.

A full account of this work, which was aided by grants from the National Institute of Arthritis and Metabolic Diseases (Grant *A*-529) of the National Institutes of Health, United States Public Health Service, the American Cancer Society (recommended by the Committee on Growth, National Research Council), the Rockefeller Foundation, and by a contract (*N6onr* 279, *T. O.* 6) between the Office of Naval Research and New York University College of Medicine, will be published elsewhere.

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METALLIC TRANSFER IN DRILLING AND ITS SIGNIFICANCE IN ORTHOPÆDIC SURGERY

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IT is common practice in modern surgery to insert pieces of metal into the body in order to strengthen or replace a damaged bone. As these are often left in place for considerable periods, it is clearly essential that they should be inert in tissues, and interfere as little as possible with repair and normal physiology. Body tissues are corrosive to most metals, and orthopædic surgeons take great care, therefore, that all the plates, screws and bolts which are to be left in a patient are of the same material and are made of metal which has a very high corrosion resistance[1]. It is well known that corrosion may be influenced by many factors. For example, mechanical deformation of the surface, differential aeration, fretting corrosion, and changes in the *p*H value of the medium all have marked effects. The relative importance of these different phenomena has been discussed by a number of workers (see, for example, Evans[2]).

In earlier communications[3,4], attention has been directed to a further factor which should be considered, namely, the nature and composition of the metal tools used to manipulate the screws, bolts and plates. It was demonstrated by a radioactive-tracer technique that it is almost impossible to insert a screw or bolt without appreciable amounts of the tool becoming plucked out and transferred to the inserted metal. Small fragments of the tool become attached to the surface of the orthopædic appliance and are buried with it in the body. It has been pointed out that although these amounts are very small (about 10–100 μgm.) the adherent particles may form corrosion centres on the surface of the buried metal. This could cause metal ions to pass into the surrounding tissue and produce a reaction which may interfere with normal physiology. Photomicrographic examination of the tissue surrounding those parts of buried metal which had been handled heavily with tools during insertion has demonstrated that such a reaction does in fact occur, even though there may be no evidence of gross corrosion.

Recent experiments have indicated that, in orthopædic operations involving the drilling of pilot-holes

Fig. 1

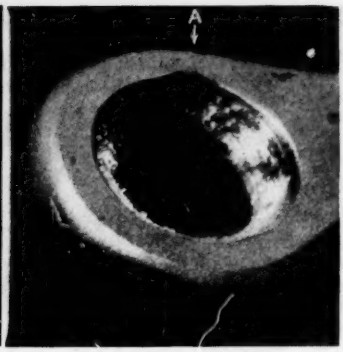

Fig. 2

Fig. 1. Hole in orthopædic plate removed from patient because of persistent sepsis; the drill had rubbed against the metal at *A*

Fig. 2. Hole in orthopædic plate; the drill has rubbed against the metal at *A*. Metal transferred from the drill to the plate at *A* may be as much as 2 mgm.

in bone the amounts of metal transferred may be very much greater than that occurring during screwing and bolting. It is usual to prepare pilot-holes in the bone to receive the screws which secure an orthopædic plate. A countersunk hole already exists in the plate, since this is prepared during its manufacture. Either engineers' twist-drills or special stainless-steel drills are commonly used for preparing the bone. Frequently such holes are drilled after a plate has already been fixed in place by two or more screws; the remaining holes of the plate are used to guide the twist-drill. Owing to the convex and wet surface of the bone, it sometimes happens that the twist-drill comes into contact with the edges of the plate-hole, and considerable friction may occur between them. Often it is desirable to insert a screw obliquely into the bone: if the pilot-hole in the bone is drilled through a plate-hole, the resulting friction may be severe. Fig. 1 shows a typical hole in an orthopædic plate which was removed because of persistent sepsis after being attached to the right tibia of a patient for five months. It is clear that the twist-drill has ground away the rim of the hole at *A*.

The transfer of metal to a plate when a pilot-hole is drilled has been measured. In the first experiment, the drills were merely allowed to touch the edges of the plates occasionally during the drilling process; in the second, oblique holes were drilled and the shoulders of the plate-holes were deliberately ground away until the damage appeared similar to that occasionally observed in plates removed from patients. Fig. 2 shows a typical experimental plate drilled in this way (compare Figs. 1 and 2).

Table 1. Transfer from Twist-Drill to Plate during drilling of Pilot-Hole for Screw
(in micrograms)

	Stainless steel plate		Vitallium plate	
	Engineers' drill	Stainless steel drill	Engineers' drill	Stainless steel drill
Drill passing freely through hole in plate, touching it occasionally	2·3	18	0·55	1·8
Drill allowed to grind against edge of plate-hole	3·0	1,500	1·2	2,000

Hardness of the Metals
(Diamond pyramid hardness in kgm./mm.²)

Stainless steel drill	400
Engineers' drill	860
Stainless steel plates	300–350
Vitallium plates	400

Table 1 shows typical amounts measured when both stainless steel and engineers' drills were used to make pilot-holes in bone through stainless steel and vitallium plates. The hardness of these metals are also given. The extremely large amounts of transfer observed with stainless steel twist-drills are probably due to the fact that the plates are as hard as the drills. When engineers' drills are used, the corresponding increase in the amount of transfer is much smaller; however, these drills are more liable to break off in the bone, thus increasing the difficulty of the operation.

It is clear that the amount of transfer occurring from the drill to the plate when a pilot-hole is drilled into bone through a plate-hole can be large: it is very much greater than that observed in screwing or bolting operations. If the twist-drill is allowed to rub against the side of the plate-hole while the pilot-hole is being drilled, the transfer can be as much as 1 or 2 mgm. The surfaces of the shoulder of the plate-hole and of the screw neck are particularly vulnerable to the onset of corrosion, for when the screw-head is seated in a countersunk hole any corrosion pores which may develop in the oxide layer will not readily be sealed by dissolved oxygen carried to the site; the close fitting of the screw-head and the countersink does not permit easy access of oxygen to these surfaces. These very large amounts of transfer, together with the subsequent differential aeration of the region, may be a cause of the gross corrosion which is occasionally observed at such points[5]. The danger of this could be diminished if drill-sleeves were used when drilling through plate-holes. Other experiments show that the amount of metal transferred from the drill to the bone itself is small.

Earlier work has shown that tiny adherent fragments of foreign metal may exert a profound influence on the surface properties of the metal to which they are attached. While they are not the only cause of the corrosion of orthopædic components, they may nevertheless be an important one and merit careful consideration. These recent observations suggest that such metallic transfer may occur in particularly large amounts when pilot-holes are drilled. The properties of the buried metal are not the only points to be considered. Attention should be given to the particular combination of the tools and the metal used, and also to the care with which the tools are handled. A full account of these investigations will appear shortly[6].

We thank Colonel J. Hickman, Department of Veterinary Clinical Studies, Cambridge, for help, and the Royal Society for a grant for equipment.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Modification of X-Ray Sensitivity of Bean Roots by Hydrogen Gas

The presence of molecular hydrogen during irradiation is known to affect radiation chemical reactions. Its influence is ascribed to the reaction $H_2 + OH \rightarrow H + H_2O$ [1], in which the very active oxidizing hydroxyl radicals disappear and hydrogen atoms arise. If hydrogen were to affect biological response to radiation, hydroxyl radicals would be strongly implicated as being responsible for part of the damage. Read[2] found no difference in the effect of radiation on growth of bean roots exposed in 14 atm. of hydrogen, or in 14 atm. of nitrogen. We have found that when gases are applied at 50 atm., hydrogen influences radiation damage differently from nitrogen.

Seedlings of *Vicia faba*[3] (Sutton's Prolific Longpod) were grown as described by Gray and Scholes. Root meristems were irradiated at 63 r. per min. with a Phillips 'Metallix' X-ray tube run at 190 kV. Reduction in growth-rate is known to be due to damage to the dividing cells of the meristem[3].

We have found that hydrogen at 50 atm. exerts a protective effect both in the presence and in the absence of oxygen. When 420 r. was given to root meristems in 50 atm. of pure hydrogen, significantly less ($P \ll 0{\cdot}01$) mortality was caused (fifteen survivors out of fifteen) than when given in 50 atm. of pure nitrogen (six survivors out of fifteen). 125 r. in 1 atm. of air plus 50 atm. hydrogen caused less mortality (thirteen survivors out of sixteen) and less reduction in growth than the same dose given in gas mixtures which contained 2 atm. hydrogen or less (thirty-eight survivors out of seventy-eight; see Fig. 1). Controls showed that the difference between the treatments was due to the presence of 50 atm. hydrogen during irradiation, and not to pressure or to the gas mixtures applied either before or after the irradiation. The depression of growth-rate six to eight days after irradiation gives a measure of radiation damage. Using Gray's data[4], we estimate the dose reduction factor for hydrogen at 50 atm. in the absence of oxygen, compared with that for nitrogen, to lie between 0·7 and 0·9. Further work is planned to obtain a more accurate value.

We interpret our results to mean that hydrogen molecules, when present in sufficiently high concentration inside the cell, alter the radiation effect by reacting with hydroxyl radicals. The hydrogen concentration must be high enough to allow hydrogen molecules to compete successfully for hydroxyl radicals with organic molecules present. This level is reached in bean roots between 14 and 50 atm. of hydrogen. Gray[5] found that the modification of radiation sensitivity in bean roots by carbon monoxide, ascribed mainly to a radical reaction, became apparent also at 40–60 atm. of the gas.

Some deductions can be made as to the damaging capacity of different radicals. Since in our experiments radiation in the presence of hydrogen results in less biological damage, we conclude that the oxidizing action of hydroxyl radicals is responsible for part of the damage caused by radiation in the bean root. If irradiation is carried out in pure nitrogen, hydrogen and hydroxyl radicals are formed from water molecules. If hydrogen is present, the concentration of hydroxyl radicals is reduced, and that of the hydrogen radicals correspondingly increased. Since biological damage is less in hydrogen than in nitrogen, it follows that hydroxyl radicals are more damaging than hydrogen radicals. If oxygen is present during irradiation, HO_2 radicals are formed by the reaction $H + O_2 \rightarrow HO_2$. The presence of oxygen during irradiation increases biological damage, indicating that HO_2 radicals are more damaging than hydrogen radicals. When hydrogen under pressure is present as well as oxygen, the number of HO_2 radicals would be expected to be larger than under any of the other conditions. Since HO_2 radicals are generally assumed to be more damaging in biological systems than hydroxyl radicals, the radiation effect would be expected to be greater when their number is increased. The contrary is, however, observed. We have no explanation to offer for this result at present.

It is probable that the reduction of growth-rate in bean roots is due in part to 'direct action' of radiation, that is, to direct energy transfer to vital non-aqueous molecules, and in part to 'indirect action', that is, to energy absorbed in water molecules which exerts its influence via chemical intermediates. On the assumption that the 'direct' effect is not altered by dissolved gases within the cells, it is possible to ascribe an upper limit to that proportion of radiation damage which is due to the 'direct' effect. If damage in the presence of pure nitrogen is taken as 1, that in air has been measured as 2·8[6], and that in hydrogen may be taken as 0·8. The latter is an upper limit for the contribution of the 'direct' effect. If bean roots are irradiated in air,

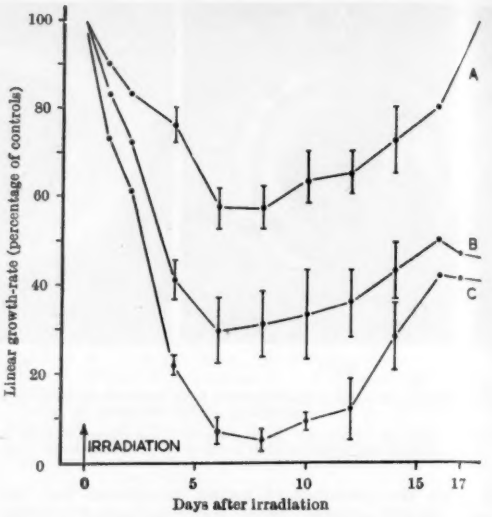

Fig. 1. Linear growth-rate of *Vicia faba* roots after exposure to 125 r. of 190 kV. X-rays plotted as per cent of growth-rate of control roots. Standard errors are shown. Curve *A*: exposure given under 50 atm. of hydrogen free of oxygen. Curve *B*: exposure given under 1 atm. of air plus 50 atm. hydrogen. Curve *C*: combined results of five groups exposed under (1) 1 atm. air; (2) 1 atm. oxygen; (3) 50 atm. oxygen; (4) 0·9 atm. oxygen plus 0·1 atm. hydrogen; (5) 48 atm. oxygen plus 2 atm. hydrogen. No differences were observed between these five groups

not more than one-third of the damage can be ascribed to the 'direct' effect.

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Deoxyribonucleic Acid Content of Marsupial Nuclei

THE deoxyribonucleic acid content of nuclei of different species of animals has been listed[1]; there appears to be a fairly regular increase from the sponges to the mammals. In the sponges the amount is about $0{\cdot}1 \times 10^{-12}$ gm. per diploid nucleus, in mammals it is about $6{\cdot}0 \times 10^{-12}$ gm. In birds the amount is only a little more than a third of that found in mammals, being about $2{\cdot}3 \times 10^{-12}$ gm. As pointed out by White[2], there is a distinct break in the distribution of chromosome numbers of the mammals, the Eutherian mammals with few exceptions having a haploid number of the order of 20–30, the marsupials of the order of 6–12. The birds and monotremes both have considerably larger numbers, and resemble the reptiles in this respect. There are, then, at least two major characters by which the higher vertebrates differ: first, the deoxyribonucleic acid content of the nucleus, and secondly, the number of chromosomes. The two do not necessarily parallel one another; but there seems to be a tendency for the groups with many chromosomes to have less deoxyribonucleic acid. The deoxyribonucleic acid content of marsupial nuclei has not heretofore been measured, and investigations of this group are reported here.

Three species of marsupial were investigated. Fresh testes of *Macropus rufus* (kangaroo) were kindly provided by Mr. Edgell, of Sydney, who removed them from three specimens, sliced them into two or three pieces and shook them in saline. Formaldehyde to a final concentration of 4 per cent was then added for preservation. Sperm were separated from this material by low-speed centrifugation and washed. The final preparations contained less than 10 per cent of other nuclei as judged by Feulgen-stained smears. The number of extra nuclei was estimated from the smears and included in the final count. Liver, gut mucosa, kidney and spleen nuclei were isolated from young *Trichosurus vulpecula* (possum) and *Perameles nasuta* (bandicoot) by the method of Marshak[3] and counted. Deoxyribonucleic acid was estimated by the method of Davidson, Frazer and Hutchison[4]. The results are shown in Table 1, with chromosome numbers (Sharman, G. B., personal communication).

Table 1

Species	Tissue	Deoxyribonucleic acid per nucleus (gm. $\times 10^{-12}$)	Diploid chromosome number
Macropus rufus	Sperm	2·9 3·1 3·4	18 + *XY*
Trichosurus vulpecula	Kidney Spleen Intestine Liver	6·6 6·0 6·4 5·0	18 + *XY*
Perameles nasuta	Kidney Spleen Intestine Liver	8·9 9·9 8·8 9·4	12 + *XX*

The deoxyribonucleic acid content of marsupial nuclei is very similar to that of Eutherian mammals and different from that of birds. We cannot account for the rather high amount found in the nuclei of *Perameles*; it is certainly not less than in Eutherian mammals. We may conclude that the big increase in nucleic acid content of the nucleus which differentiates birds and mammals and appears to accompany a difference in chromosome number took place before mammals were differentiated into Eutherian and Marsupial forms.

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Crystalline Cytochrome *c* from the King Penguin

CYTOCHROME *c* was prepared from skeletal (mainly pectoral) muscle of the king penguin (*Aptenodytes patagonica*) by the method of Keilin and Hartree[1,2] and further purified with the aid of the ion-exchange resin 'Amberlite *XE*-64', by the method of Margoliash[3].

Attempts were made to crystallize the protein by saturating 1–2 per cent aqueous solutions with ammonium sulphate at various *p*H's. From solutions of ferri-cytochrome only spherulitic globules were obtained, which did, however, exhibit birefringence between crossed nicols. But if a neutral solution of cytochrome, almost saturated with ammonium sulphate, was reduced by adding a trace of sodium dithionite, the reduced cytochrome was precipitated slowly in the form of true crystals possessing flat faces and exhibiting straight extinction between crossed nicols. The crystals have the form of thin plates, as shown in Fig. 1. Crystalline preparations of cytochrome *c* have not hitherto been reported in the literature.

The precipitate, which was almost completely crystalline, was centrifuged off and its enzymatic activity compared with that of purified horse cytochrome *c*. Two methods were used: (*a*) the cytochrome oxidase system with ascorbic acid as reducing

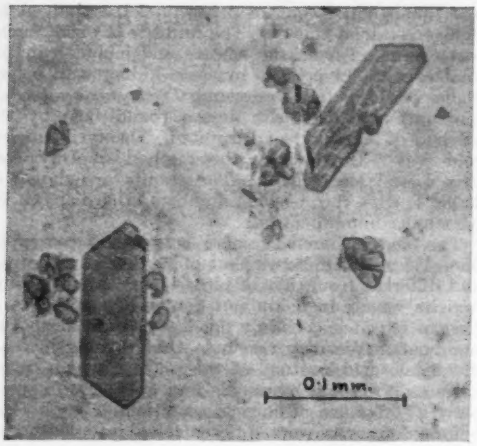

Fig. 1. Two crystals of cytochrome *c* (lower left and upper right)

agent, and (*b*) the succinic oxidase system (Keilin and Hartree[2,4], Slater[5]), using excess of heart muscle preparations deficient in cytochrome *c* (Tsou[6]) and limiting amounts of cytochrome *c*. By each method the activity of the crystalline king penguin cytochrome *c* was found to be, within the limits of error, identical with that of horse cytochrome *c*.

Measurements of the iron content and absorption spectrum of king penguin cytochrome *c* were made using purified stock solutions. The iron content was found to be 0·430 and 0·444 per cent in two separate preparations (for the horse heart pigment the standard figures range from 0·43 to 0·46 per cent iron). The absorption spectra of ferri- and ferro-cytochrome *c* of the king penguin were found to be identical with those of horse and beef cytochrome *c* within the limits of error. Thus the extinction coefficients of the α-, β- and Soret bands correspond within 3 per cent to the values given for beef cytochrome *c* by Theorell[7]. The ratio of the extinction coefficients of the reduced form at 550 mμ to that of the oxidized form at 280 mμ was found to be 1·15, as compared with 1·17 for beef (Paleus[8]).

I thank the Director of the Zoological Society of London for providing the king penguin muscle, and Prof. D. Keilin, Dr. E. F. Hartree and Dr. A. Tissières of the Molteno Institute, University of Cambridge, for the sample of purified horse cytochrome *c*, for the heart-muscle succinic oxidase preparation and for providing facilities and help in carrying out the determination of enzymatic activity.

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Enzymatic Conversion of Alpha-Formamidinoglutaric Acid to Glutamic Acid by Rat Liver

A previous report from this laboratory[1] gave evidence that histidine is converted to glutamic acid *in vivo* and *in vitro*. The *in vitro* experiment, done with guinea pig-liver slices, is subject to the criticism that degradation of α-formamidinoglutaric acid, the principal conversion product, may have occurred non-enzymatically. Direct evidence for such a conversion has been found so far only in micro-organisms adapted to histidine[2]. I have now shown the presence in rat liver of an enzyme which degrades α-formamidinoglutaric acid (N-formiminoglutamic acid) to glutamic acid.

Radioactive α-formamidinoglutaric acid was prepared by incubating homogenized rat liver with L-histidine-^{14}COOH (20,000 counts/min. per mgm. or 3,100 counts/min. per μmole) at 37° C. for 18 hr., precipitating the proteins with trichloracetic acid and separating the radioactive products by elution with hydrochloric acid from a column of 'Dowex-50' resin. The fraction containing α-formamidinoglutaric acid (200–280 ml. of 1·5 *N* hydrochloric acid) was lyophilized and stored in aqueous solution at *p*H 2–3. The radioactive α-formamidinoglutaric acid had an R_F on paper of 0·28 with 3 parts *n*-propanol/1 part 1·0 *N* acetic acid as solvent. It gave a delayed ninhydrin reaction (purple) and an immediately positive alkaline ferricyanide–nitroprusside reaction (pink)[3]. Synthetic α-formamidinoglutaric acid, kindly supplied by Dr. Alexander Miller[4], had identical R_F and colour reactions. α-Formamidinoglutaric acid is unstable in the presence of 1·0 *N* sodium hydroxide and is converted to a compound identical, by the above column and paper chromatographic procedures, with glutamic acid.

α-Formamidinoglutaric acid so prepared was converted to glutamic acid enzymatically by a soluble rat-liver preparation. A rat liver was homogenized at 0–4° C. in 20 ml. of 0·1 *M* potassium phosphate buffer, *p*H 7·8, and centrifuged at 100,000 *g* for 1 hr. The clear supernatant (protein nitrogen = 2·0–3·5 mgm./ml.) was incubated at 37° C. for 2 hr. in varying concentrations in a total volume of 1·0 ml. (0·1 *M* in potassium phosphate buffer, *p*H 7·8) with 2,000 counts/min. (= 0·65 μmole) α-formamidinoglutaric acid. The reaction was stopped with trichloracetic acid, and the filtrate put on a small column (0·3 cm. × 55 cm.) of 'Dowex-50'. The column was eluted with 1·5 *N* hydrochloric acid, and fractions of 0·5 ml. were collected. These were evaporated to dryness and tested for radioactivity. Unaltered α-formamidinoglutaric acid was recovered in fractions 18–25. A radioactive peak in fractions 11–15 was identical on paper chromatography with glutamic acid, giving an immediate ninhydrin colour (purple) and no colour with alkaline ferricyanide – nitroprusside. No other radioactive peaks were obtained.

Enzyme activity was measured with enzyme (1) unmodified, in varying concentrations, (2) boiled for 10 min., (3) incubated in the presence of 0·01 *M* glutathione, (4) incubated in the presence of 0·0025 *M* *p*-chloromercurobenzoate, (5) pre-incubated 2 hr. at 37° C. with and without glutathione, and (6) incubated in the presence of folic acid (1×10^{-4} to 5×10^{-3} *M*) with glutathione. The percentage conversions to glutamic acid (calculated from amounts formed and α-formamidinoglutaric acid remaining) under various conditions are shown in Table 1.

Table 1. Conversion of α-Formamidinoglutaric Acid to Glutamic Acid

Enzyme	Protein nitrogen (mgm.)	Percentage conversion to glutamic acid
None	0	0
Boiled	0	0
Unmodified	1·0	100
Unmodified	0·6	83
Unmodified	0·5	65
Unmodified	0·3	36
Unmodified	0·2	20
Glutathione added	0·3	74
Folic acid + glutathione	0·3	0
p-Chloromercurobenzoate	1·0	22
Preincubated	1·0	33
Preincubated + glutathione	1·0	85

It is concluded that rat liver contains an enzyme, which can be solubilized, and which catalyses the degradation of α-formamidinoglutaric acid to glutamic acid, without the accumulation of any intermediate. Similar homogenates degrade histidine to α-formamidinoglutaric acid much more rapidly. The enzyme which degrades α-formamidinoglutaric acid is unstable, but less so in the presence of glutathione. Low activity and instability of this enzyme probably account for the accumulation of the acid when histidine is incubated with liver homogenate. Folic acid inhibits the enzyme, thereby raising the question whether it is acting as an analogue of a coenzyme such as tetrahydrofolic acid.

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Benzene-$^{14}C_1$ from the Neutron Irradiation of the Clathrate with Ammoniacal Nickel Cyanide

The use of *in situ* production of compounds containing carbon-14 by the neutron irradiation of nitrogen-containing organic compounds or mixtures of nitrogen-containing compounds with organic compounds for the synthesis of labelled organic compounds has been suggested by recent work on this subject[1,2]. The neutron irradiation of the clathrate of ammoniacal nickel cyanide and benzene was reported on by M. Zifferero[3] in Genoa last year. We have carried out an irradiation of this compound to provide data for comparison and to test a purification method for labelled compounds produced in this way.

Pile irradiation conditions with regard to the ratio of fast to slow neutrons and the intensity of the gamma-field vary from one installation to another. Arrangement of the sample in the lattice of a pile with regard to proximity of the fuel rods and quantity of absorber surrounding the sample will also affect the exact irradiation conditions.

A 21·4-gm. sample of clathrate prepared by the method of Hofmann and Hochtlen[4] was irradiated in the Brookhaven pile for thirteen days at a sample temperature of 30° C. The thermal neutron flux was about 4×10^{12} neutrons/cm.^{2} sec., the fast neutron flux about 10^{12}, and the gamma flux was equivalent to about 5×10^6 r./hr. The irradiated sample proved to be quite γ-active. This activity was identified as cobalt-58 by Dr. M. L. Perlman of this Laboratory. The probable source is the $^{58}Ni(n,p)^{58}Co$ reaction. The clathrate was decomposed by the method of Turner and Warne[5] with some modification of the collection system. The benzene was dried and distilled from sodium. To allow greater ease in manipulation, distilled active benzene was diluted with inactive benzene and the dilute sample fractionated twice in a 50-plate (*n*-heptane, methyl *cyclo*hexane calibration) concentric tube column.

Ortho-benzoylbenzoic acid was prepared from the benzene, and anthraquinone was then made from this derivative. Careful purification of each derivative showed no change in specific activity relative to the parent benzene when corrected for the introduction of inactive carbons. Our results are presented in Table 1.

Table 1

Sample	Carbon-14 activity (mμc./mgm. carbon)
Irradiated clathrate	29·6
Recovered benzene distilled from sodium	0·835
Fractionation No. 1 of diluted benzene	
Head cuts	0·068
Centre cut	0·065
Tail cut	0·064
Fractionation No. 2 of diluted benzene[b]	
Head cuts	0·066
Tail cut	0·062
o-Benzoyl benzoic acid	0·061[d]
Anthraquinone	0·063[d]
Corrected value for recovered benzene[e]	0·630

[a] These fractions were taken from a boiling plateau with a 0·2 deg. range.
[b] Three cuts from previous fractionation combined.
[c] Boiling points of cuts within 0·05 deg. of each other.
[d] Corrected for dilution by eight additional carbons.
[e] Using 0·062 as the value for diluted benzene at constant specific activity.

Quantitative recovery of benzene was not attempted; however, very little is lost by radiation damage. Difficulty in obtaining precise carbon values for the clathrate made it necessary to rely on the nickel and nitrogen values in order to calculate the total amount of benzene present. The carbon-14 activity as benzene represents 1·44 ± 0·13 per cent of the total carbon-14 activity produced. The stated error is exclusive of any error introduced in the radioactive assay. The percentage is calculated by simply using the following formula:

$$\frac{\text{Benzene activity (mμc./mgm. carbon)}}{\text{Clathrate activity (mμc./mgm. carbon)}} \times \frac{\text{total mgm. carbon due to benzene}}{\text{total mgm. carbon in sample used}} \times 100 = \% \text{ of total activity}$$

Had the analysis been ideal, the carbon-14 activity in benzene would have been 1·59 per cent.

The value reported by M. Zifferero[3] was 4 per cent. The method of calculation was not stated.

The actual levels of activity produced in recognizable compounds is still rather lower than one might desire for labelled compounds. In a system where a carbon analogue is produced, such as the acridine to anthracene sequence[2], it may in the future

be possible to isolate the analogue free from carrier. It must be borne in mind, however, that at the present time these compounds are formed in quantities too small for practicable separation.

Investigations on the chemical fate of a recoiling carbon-14 atom are being carried out. It is hoped that the increasing amount of research in this field will provide accurate data for the correlation of re-entry versus total carbon-14 production in a given system. In addition, the method may become a valuable synthetic tool for the organic chemist.

This investigation was carried out under the auspices of the U.S. Atomic Energy Commission.

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Steric Effects in the Formation of Copper and Cobalt Complexes with the Epimeric Salicylidenementhylamines

In a previous communication[1], it was reported that cobaltous ions do not react readily with salicylideneaniline bases bearing ortho substituents on the aniline ring. In the present communication are reported some further attempts to prepare similar complexes of cobalt and copper, using as the amine components of the salicylidene bases four epimeric forms of menthylamine which, with bulky *iso*propyl substituents and nonplanar ring forms, may be expected to exert considerable steric resistance to a tetrahedral grouping of ligands about cobalt ions. The complexes were prepared by mixing aqueous solutions of the metal acetates with an alcoholic solution of the salicylidene base[2]. The results of this work are indicated in Table 1, the complexes isolated being of the form *bis* (salicylidenementhylamine) cobalt (copper).

Table 1

Amine component	Co	Cu
Cyclohexylamine	+	+
(−)-Menthylamine	+	+
(+)-*neo*Menthylamine	−	−
(+)-*iso*Menthylamine	0	+
(±)-*neoiso*Menthylamine	0	+

+ = isolation of the complex *bis* (salicylideneamine) *M*.
− = no reaction: formation of metal hydroxide and unchanged Schiff's base.
0 = formation of oils or tar and unchanged Schiff's base.

The inability of salicylidene-(+)-*neo*menthylamine to form complexes with either cobalt or copper points to a strong steric hindrance with respect to both the nitrogen atom and the phenolic hydroxyl in this case. (−)-Menthylamine and (+)-*neo*menthylamine differ only in the configuration of the amino-group at $C_{(2)}$, and the ready formation of complexes with (−)-menthylamine (with both copper and cobalt) is explainable on the basis of this relationship. A consideration of the probable conformations of strainless rings for the amines[3,4] suggests that the *cyclo*hexane ring contributes considerably to the steric hindrance preventing complex formation with (+)-*neo*menthylamine, in which the amino-group occupies an axial position, whereas no such effect impedes complex formation with (−)-menthylamine, which has an equatorial amino-group.

With copper and salicylidene-(+)-*iso*menthylamine the expected complex was isolated as readily as in the case of (−)-menthylamine; but with cobalt the reaction produced only a reddish tar together with unchanged base, and no solid complex could be isolated from the mixture. It is not immediately obvious why cobalt does not form a derivative with the (+)-*iso*menthylamine base while copper does, even on the assumption of a tetrahedral arrangement for the expected cobalt complex. This difference observed between the behaviour of salicylidene-(−)-menthylamine and that of salicylidene-(+)-*iso*menthylamine towards cobalt ions was not expected, as the difference between the two amines is believed to be only in the position of the methyl group (1*e* in the case of menthylamine and 1*p* in *iso*menthylamine[4]).

Although no complex could be obtained with cobalt and salicylidene-(±)-*neoiso*menthylamine, but only a reddish tar and unchanged Schiff's base, the copper derivative, on the other hand, was readily isolated. The lesser hindrance towards complex formation of (±)-*neoiso*menthylamine compared with that of (+)-*neo*menthylamine is in agreement with the greater reactivity of *neoiso*menthol over that of *neo*menthol towards acid chlorides[5]. If the inability of salicylidene-(+)-*neo*menthylamine to form complexes with both copper and cobalt ions is due chiefly to the spatial arrangement of the *iso*propyl and amino-groups, it seems unlikely that *neoiso*menthylamine has, in these reactions at least, a conformation in which the amino-group occupies an axial position. Rather, our results tend to support the view that *neoiso*menthyl derivatives are examples of conformational instability (Mills, J. A., private communication), and that it is possible for the amino-group in *neoiso*menthylamine to adopt an equatorial position[3].

Relative pK_a values have been determined for the four menthylamine epimers by potentiometric titration in 50 per cent aqueous ethanol against hydrochloric acid. As can be seen from Table 2, the order of decreasing basic strength is *iso*menthylamine, menthylamine, *neo*menthylamine, and *neoiso*menthylamine.

The apparent non-reactivity of several of the salicylidene-menthylamine bases with cobalt, and of the *neo*menthylamine derivative with copper and cobalt cannot be ascribed to differences in the basicities of the amines. They are all comparably strong bases, and the electron density on the nitrogen atom in each case should not differ greatly throughout the series. Steric effects related to the tendency to form planar (copper) or tetrahedral (cobalt) derivatives as outlined above seem to provide the only

Table 2. pK_a Values of Four Epimeric Menthylamines determined in 50 per cent Aqueous Ethanol at 20°

	pK_a
(+)-*iso*Menthylamine	9·93
(−)-Menthylamine	9·73
(+)-*neo*Menthylamine	9·69
(−)-*neoiso*Menthylamine	9·47

other explanation of the difference in reactivity between copper and cobalt with the various bases studied.

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Crystallization of Silver Chromate

The precipitation of silver chromate from its supersaturated solutions has been studied by van Hook[1], who concluded that crystallization could be represented as a two-step process: first, an induction period varying inversely with the volume of seed suspension used, during which the principal action was the generation of crystal nuclei; secondly, a bimolecular growth of these nuclei.

It is well known that the inoculation of supersaturated solutions with seed crystals results in the growth of these added crystals rather than the formation of crystal nuclei[2]. Crystallization of silver chloride begins immediately on seeding a supersaturated solution. Delayed crystallization, however, similar to that reported by van Hook, is encountered when seed suspensions are aged before use in the presence of suitable poisoning substances such as eosine[3]. The observed inverse relationship between the duration of these induction periods and the volumes of poisoned suspension used suggests that the results of van Hook were due to the presence of adsorbed contaminant at the surface of aged silver chromate crystals. The present work was designed to test this suggestion.

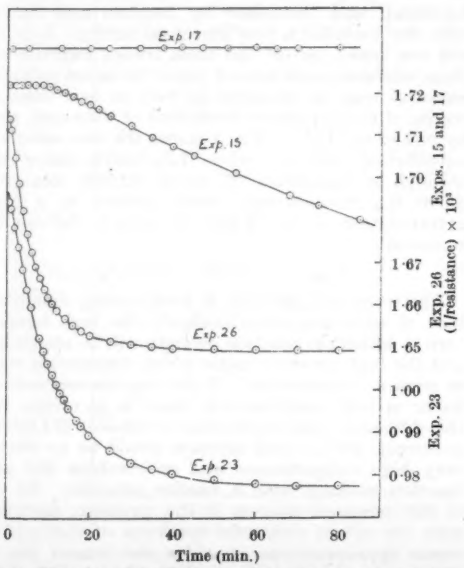

Fig. 1. Time plots of the reciprocal of the resistance of the solution

Preliminary experiments confirmed the existence of a well-defined critical supersaturation: it was possible to prepare stable solutions of silver chromate in which the molar concentration product $[Ag^+]^2[CrO_4^=]$ exceeded the solubility value by more than 300 per cent. The solubility of silver chromate at 25° was determined by the equilibration (*a*) of pure solid with conductivity water ($0{\cdot}923 \times 10^{-4}$ moles/l.), and (*b*) of highly supersaturated solutions ($0{\cdot}931 \times 10^{-4}$ moles/l.).

Crystallization experiments were carried out at 25° using the conductivity technique described elsewhere[3]. Supersaturated solutions of silver chromate were prepared in a stirred conductivity cell by mixing silver nitrate and potassium chromate solutions, and crystallization was induced by the addition of a small volume, usually 5 ml., of the appropriate seed suspension. Some typical results are shown in Fig. 1, in which the reciprocal of the resistance of the solution (a measure of the extent of crystallization) is plotted against time.

Solubility product = $3{\cdot}186 \times 10^{-12}$

Experiment	Initial concentrations moles/l. × 10^4 $[Ag^+]$	$[CrO_4^=]$	$[Ag^+]^2[CrO_4^=]$ × 10^{12}
15	2·234	1·129	5·635
17	2·250	1·130	5·720
23	2·254	1·127	5·726
24	3·580	0·448	5·725
26	1·420	2·840	5·727

An aged seed suspension, prepared by crystallization from boiling saturated silver chromate solution, was used in Exp. 17 and no change in conductivity was detected for at least four hours, even though a sensible supersaturation persisted. Thorough washing of this aged suspension with boiling conductivity water before use in Exp. 15 resulted in a substantial reduction in the time of induction. In Exps. 23, 24 and 26, the use of freshly precipitated seed suspension of available growth area less than half that of the aged suspension enabled crystallization to start immediately on seeding. These results provide conclusive evidence that any induction effect is due to contamination of the surface of aged crystals. Hydrolysis products, the most likely contaminants, might include any or all of the species $HCrO_4^-$, $AgOH$, Ag_2OH^+.

It is seen from Fig. 2 that the rate of crystallization, $-dm/dt$ (moles.l.$^{-1}$min.$^{-1}$), obtained from the curves in Fig. 1, is best interpreted in terms of third-order

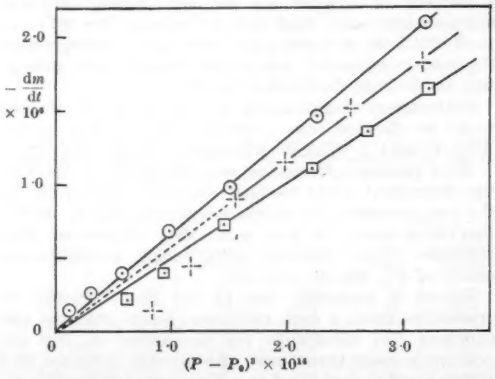

Fig. 2. Third-order kinetic plot. Exp. 23, ⊙; exp. 26, +; exp. 24, ⊡

kinetics: $-dm/dt = k(P - P_0)^2$, where k is a constant, $P = \{[Ag^+]^2[CrO_4^=]\}^{1/3}$ at any instant, and P_0 is its solubility value. By analogy with the observed second-order kinetics for crystallization of silver chloride[2], these results may be interpreted in terms of the simultaneous arrival of two silver ions and one chromate ion at the hydrated monolayer assumed to be adsorbed at the surface of the crystals.

At non-equivalent ionic concentrations of silver and chromate, the presence of an excess of chromate ions (Exp. 26) produces a greater reduction in the rate of crystallization in the later stages than is to be expected for a termolecular process. This may be due to the adsorption at the growing surface of $HCrO_4^-$ ions, formed by hydrolysis of chromate ions, effectively reducing the number of available growth sites.

Studies of both crystallization and dissolution processes are being continued.

We thank Prof. C. W. Davies for his interest in the work.

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Radioactivity of Zircons

Mügge[1] recorded the α-particle emission of zircons by sprinkling them on a photographic plate and, more recently, Tyler and Marais[2] have used a similar technique for determining the relative radioactivities of mineral grains. In both experiments, the mineral grains were mounted on the surface of the photographic emulsion.

We have attempted quantitative measurement and comparison of the α-activities of zircons by embedding them completely in 'Nuclear Research' photographic emulsions, using a method very similar to that used by King, Traczyk and Harris[3] in the study of Protozoa by electron-track radiography.

Zircons obtained from a Triassic sandstone of the Bristol district were sprinkled evenly on the emulsion surface of Ilford *C*2, 50μ, 'Nuclear Research' plates, and some *C*2 gel was liquefied and poured over them, so that the grains were completely surrounded by photographic emulsion. The plates were dried in a current of filtered air for two hours at room temperature, and then left to 'expose' for 20 days at 2–3° C. in a light-tight box in a refrigerator. Processing revealed α-particle tracks surrounding, and in contact with, the zircons.

Preliminary examination showed that the zircons could be divided into a strongly radioactive group (Fig. 1) and a weakly radioactive group (Fig. 2).

More precise information was obtained by dividing the estimated total surface area of each grain by the total number of α-tracks associated with it. When this was done, it was seen that zircons of four activities were present with mean area/emission ratios of 18, 40, 85 and 250.

Zircon is probably one of the first minerals to crystallize from a rock melt, and since uranium and thorium can substitute for zirconium in the zirconium silicate structure[4], the specific activity of a zircon can be considered as a function of the uranium–thorium concentration in the parent rock magma.

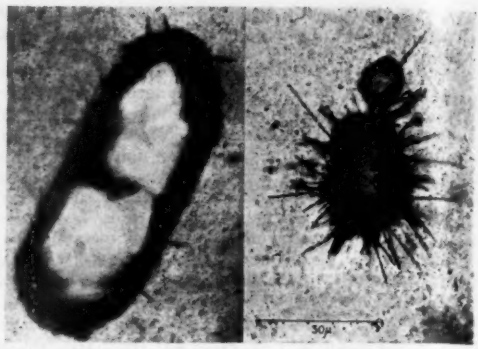

Fig. 1. Zircon grain of low activity from Triassic sandstone, Bristol
Fig. 2. Zircon grain of high activity from Triassic sandstone, Bristol

Zircon is therefore 'labelled', and, we suggest, can be used as a natural radioactive tracer. Since it is an extremely durable mineral[5], the technique described should prove useful in many petrological problems, particularly those of provenance in sedimentary petrology.

A more detailed account of this work will be published elsewhere.

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The Graphite–Diamond Equilibrium

There have very recently been two recalculations of the graphite–diamond equilibrium, one by Liljeblad[1] and the other by Berman and Simon[2], who also included a brief historical survey. Liljeblad did not make use of the most recent experimental data, whereas in the second paper the latest published material was incorporated as well as new measurements of the expansion coefficient of diamond, made by one of us (J. T.). Fig. 1 shows the two calculated equilibrium curves; while Liljeblad's curve goes through a maximum of about 62,000 atm. near 3,000° K., Berman and Simon arrived at a linear extrapolation above 1,200° K., which follows the equation:

$$P_{(atm.)} = 7{,}000 + 27\,T_{(°K.)}$$

The technical difficulty in synthesizing diamond is that of achieving, simultaneously, the high temperature at which the reaction velocity will be appreciable and the high pressure under which diamond is stable at such a temperature. If the equilibrium curve is linear at high temperatures, there is no escape from this difficulty in an equilibrium synthesis. If Liljeblad is correct, the obvious solution would be to work at very high temperatures and so combine the great reaction velocity with a smaller pressure. In view of the increased interest in this problem, associated with the recent successful synthesis of diamond[3], it seems appropriate to consider the reason for the discrepancy between the calculations.

New values of the densities and of the low-temperature specific heats of diamond and graphite introduce only slight changes, and the difference between the two curves is almost entirely due to the different values of the expansion coefficient of diamond used in the calculations. This coefficient is important because it affects the difference of the specific heats,

$$C_p - C_v = \frac{(3\alpha)^2 TV}{K}$$

where α is coefficient of linear expansion, V is atomic volume and K is compressibility. Although C_v for diamond and graphite may be equal at high temperatures, a large expansion coefficient, combined with low compressibility, would make C_p for diamond much bigger than for graphite.

High-temperature determinations of the coefficient of expansion of diamond have been made by Joly[4], using an optical method, and by Krishnan[5], using X-rays. The results are shown in Fig. 2, together with the low-temperature measurements of Dembowska (quoted by Röntgen[6]). If Joly's values were correct we should have a very severe violation of Grüneisen's law of the proportionality of thermal expansion coefficient to specific heat. It is true that slight deviations from this law have recently been observed at low temperatures[7]; but it is difficult to see how a serious departure could occur at high temperatures. As a further check, the Grüneisen constant, γ, can be calculated from the relation, $3\alpha = k\gamma C_v/V$, and for most substances γ is found to lie between 1 and 2. Grüneisen[8] had derived values of 1·1–1·2 from Dembowska's measurements, and Krishnan showed that his results satisfied the Grüneisen relation with γ about 1·3. According to Joly's results, γ would increase rapidly to more than 3.

Before accepting such a departure from Grüneisen's law, one must be convinced of the reliability of the measurements involved. A consideration of Joly's apparatus, however, led us to doubt his accuracy and to undertake a new X-ray determination of the lattice constant up to about 1,200° K. Fuller details of these experiments will be published later, and in Fig. 2 we only show the high-temperature end. At 1,200° K., we find γ to be 1·3, in agreement with Krishnan's value for lower temperatures. To show more fully how well the expansion, according to the new measurements, obeys Grüneisen's law, we give in Table 1 the ratio of the change of lattice constant to the change of heat content, over several temperature intervals. It can be seen that, apart from a suggestion of a very slight anomaly between 400° and 600° K., the ratio of these two quantities remains sensibly constant. The thermal expansion of diamond is therefore quite normal, and the only justifiable extrapolation to higher temperatures should follow Grüneisen's law.

Thus Joly's results are certainly in error. Liljeblad only states the value he has assumed for 3α at 2,300° K. (α is plotted in Fig. 2), without giving his sources. This unjustifiably high value would increase $C_p - C_v$ of diamond to 2 cal./mol.-deg. and is

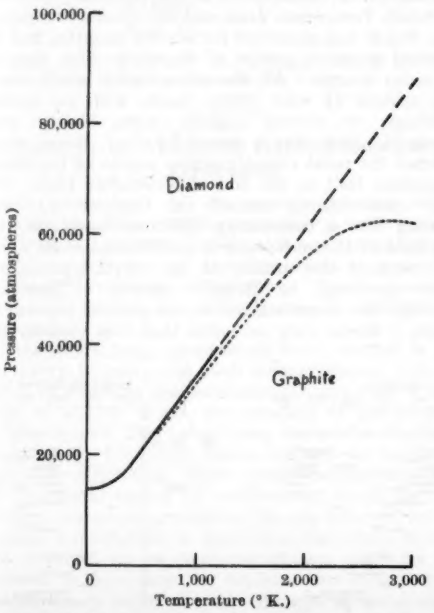

Fig. 1. Calculated graphite-diamond equilibrium curve. Berman and Simon, ———, calculated to 1,200° K.; — — —, linear extrapolation. Liljeblad, ·····

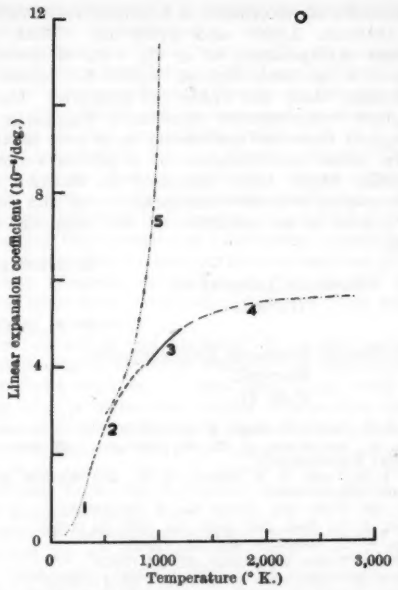

Fig. 2. Coefficient of linear thermal expansion of diamond. (1) Dembowska, ·····; (2) Krishnan, – – – –; (3) Thewlis (only the high temperature end is shown), ———; (4) Extrapolation according to Grüneisen relation, — · — · —; (5) Joly, — · · — · · —. Value quoted by Liljeblad, O

Table 1. Comparison of Changes in Lattice Constant (Δa) and Changes of Heat Content (ΔH) with Temperature, for Gem Quality and for Industrial Diamonds

Temp. interval (°K.)	Δa (10^{-4} A.) Gem stones	Δa (10^{-4} A.) Industrial stones	ΔH (cal./mol.)	$\Delta a/\Delta H$ (10^{-4} A. mol./cal.) Gem stones	$\Delta a/\Delta H$ (10^{-4} A. mol./cal.) Industrial stones
300–400	55	50	200	0·28	0·25
400–500	85	90	265	0·32	0·34
500–600	111	104	345	0·32	0·30
600–700	117	110	415	0·28	0·27
700–800	131	131	450	0·29	0·29
800–900	138	143	475	0·29	0·30
900–1,000	148	150	495	0·30	0·30
1,000–1,100	158	159	510	0·31	0·31

responsible for the maximum in Liljeblad's equilibrium curve between 2,500° and 3,000° K. With the Grüneisen extrapolation of α, $C_p - C_v$ of diamond is only 0·2 cal./mol.-deg. at 2,300° K., which is little greater than the value for graphite. Up to the highest temperatures considered, $C_{p(\text{diamond})} - C_{p(\text{graphite})}$ is therefore sufficiently near zero so that, with the other uncertainties, of a similar order of magnitude, which were discussed in Berman and Simon's paper, a linear extrapolation of the equilibrium curve is as accurate as the existing data warrant.

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Location on Jupiter of a Source of Radio Noise

A search of old records of cosmic noise, taken in the Radiophysics Laboratory at 18·3 Mc./s., has confirmed the discovery, by Burke and Franklin[1], of radio radiation from Jupiter, and has further shown that in 1951 the radio radiation came from a very localized region of the planet.

The records studied fall into two series. The first series comprised records, using an aerial with beam-width 17°, taken at intervals during the period October 1950–April 1951. Radiation from Jupiter appeared on about one-half of the days on which records were suitable (correct aerial direction, no obvious interference, etc.), and it was clear that the right ascension of the source changed with that of Jupiter. For some of these records more accurate direction-finding was possible using a split-beam technique, and these records proved that the position of the source was within ± 1° of Jupiter.

The second series of records had been taken with the aerial modified in such a way that the beam was still narrow in declination but was very broad in hour angle. Because of its broad beam it was capable of receiving signals from an extra-terrestrial source for nearly eight hours per day—a time which would cover nearly one complete rotation of Jupiter. This series of records, from August 15 to October 2, 1951, revealed Jupiter radiation on twenty-seven out of the thirty days on which there were suitable records, although on all days the bursts of radiation came in groups only an hour or two in duration.

A most interesting new fact coming out of the examination of these records was the very close relation between the times of occurrence of bursts and the rotation of Jupiter. For each record the times of activity were noted. Fig. 1 shows the longitudes of the central meridian during the times when bursts were received. The equatorial regions of the visible surface of Jupiter rotate more rapidly than the remainder of the planet and two conventional systems of zenocentric longitude are used. System I, which applies to the equatorial regions, is based on a rotation period of about 9h. 50m.; system II on a rotation period of about 9h. 55m. It will be seen that the lines indicating times of occurrence of bursts are almost directly under one another when plotted against system II longitudes and show a steady drift towards increasing longitudes in system I. Closer examination shows that there is actually a small negative drift in the system II diagram. These drifts imply that the source of radiation had a rotation period slightly shorter than that adopted for the calculation of system II longitudes; the period of rotation is found to be 9h. 55m. 13s., with an estimated probable error of ± 5s.

After allowing for the slight drift in longitudes, all the lines in Fig. 1 were superimposed to give a histogram of the frequency of occurrence of the noise for 5° intervals of central meridian longitude. This is shown in Fig. 2, the longitudes being system II longitudes on August 14. This figure shows that for a band of longitudes centred on 67° and extending from about 0° to 135°, the frequency of occurrence was much greater than outside this band. This suggests an origin in a very localized source on Jupiter. Since there were about 120 rotations of Jupiter during the period of the observations on which the figure is based, the probability that the effect observed is due to chance is extremely small.

Fox[2] has given a summary of the observations of Jupiter at this time which were communicated to the Jupiter Section of the British Astronomical Association. A disturbance at the boundary between the South Temperate Zone and the South Temperate Belt, which was observed for several months, had an observed rotation period of 9h. 55m. 13s., that of the radio source. All the other belts which move with system II were either faint, with no certain markings, or moved slightly more slowly than system II. Fox gave a sketch by E. J. Reese which depicted the most visually active region of the South Temperate Belt at the end of November 1951. The radio observations ceased on October 2; but, allowing for a continuing drift in longitude, the longitude of the radio source on November 30 would have crossed the middle of one of the prominent white markings in Reese's sketch. Therefore, although the identification is not proved beyond all doubt, it seems very probable that this visually dis-

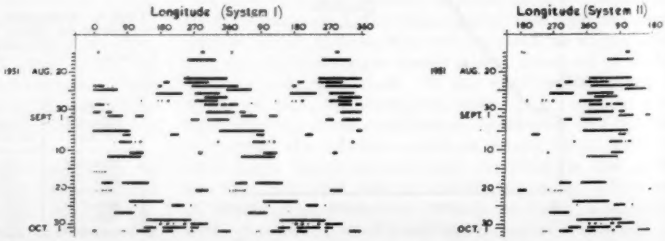

Fig. 1. Periods of occurrence of 18·3 Mc./s. radiation from Jupiter plotted against longitude of the central meridian at the time of observation

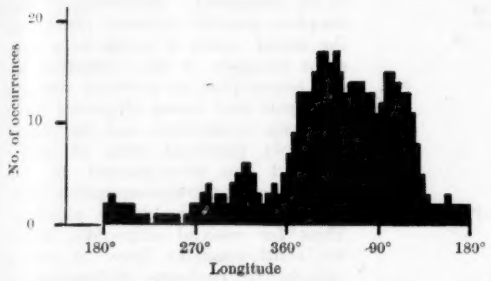

Fig. 2. Frequency of occurrence of 18·3 Mc./s. radiation from Jupiter for intervals of 5° in longitude (based on a rotation period of 9h. 55m. 13s.). The longitudes are system II longitudes on August 14, 1951

turbed region was responsible for the radio radiation, the most intense source lying in one of the white spots at the southern edge of the South Temperate Belt.

The mechanism of origin of the radiation is still unknown. Observations during the past few months have confirmed a result suggested by the 1950–51 observations that the individual bursts have durations ranging from fractions of a second to many seconds. An origin in electrical discharges analogous to terrestrial atmospherics is not unlikely. The recent observations are also consistent with the hypothesis of a localized source of the radiation.

A full discussion of the 1950–51 observations will be given in a paper submitted to the *Australian Journal of Physics*.

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Mechanism of Uniform Field Breakdown in Hydrogen

Any assessment of the validity of theories of electrical breakdown of gases in uniform fields requires an accurate knowledge of breakdown potentials and of the magnitudes of the fundamental ionization processes involved. Preferably these quantities should be determined under the same experimental conditions.

Some years ago, experiments were started in this laboratory to carry out such measurements with the object of checking the streamer theory[1] over a wide range of values of pd, the product of gas-pressure and gap-length. Since that time, the results of experiments of F. Llewellyn-Jones and his co-workers[2,3] have been published. Their results demonstrate that the Townsend theory of breakdown, involving (i) a primary ionization process in the gas denoted by the Townsend coefficient α, and (ii) a secondary process here denoted by γ probably taking place at the cathode, is adequate to explain the initiation of breakdown in both air and nitrogen up to a value of pd of about 1,000 cm. mm. mercury. Our results in air lend support to this view, and it is the purpose of this communication to report the results of similar experiments in hydrogen.

Determinations have been made, at a number of values of the ratio of electric field-strength to pressure, E/p, of the growth of current as the gap-length, and consequently pd, is increased to within a few per cent of the breakdown value. A plot of ln i against gap-length d has a form similar to that obtained for air, having an initial linear region from which a value of the Townsend coefficient α can be obtained, followed by a region of increasing gradient indicating the presence of a secondary ionization process. A typical series of curves obtained at 700 mm. mercury pressure is shown in Fig. 1, and similar curves have been obtained at 300 mm. and 100 mm. mercury pressure.

The values of α/p obtained from the curves are shown in Fig. 2, together with the results in hydrogen of previous workers. It has been found that in the range of E/p where the results obtained at different pressures overlap, there is agreement in the values of α/p within the limits of experimental error. The fact that α/p is truly a function of E/p has not previously been experimentally demonstrated over a wide pressure range.

There is general agreement in the values of α/p obtained by all workers when $E/p > 25$ volts/cm./mm. mercury; but for $E/p < 22$ the results of this work show considerable divergence from those of Ayres[4] and the microwave measurements of Brown[6] *et al.* The value of α/p at $E/p = 15$ V./cm./mm. mercury is almost two orders of magnitude smaller than that obtained by Ayres. It should be pointed out, however, that the measurements of Ayres[4] in nitrogen are greater by a number of orders of magnitude at low E/p than the more recent results of Masch[7], Posin[8] and Dutton *et al.*[3].

It is of particular interest that, over the range of E/p studied, the results are in very good agreement with the calculations of Emeléus, Lunt and Meek[9], which are based on the assumption of a Maxwellian distribution of electron energies.

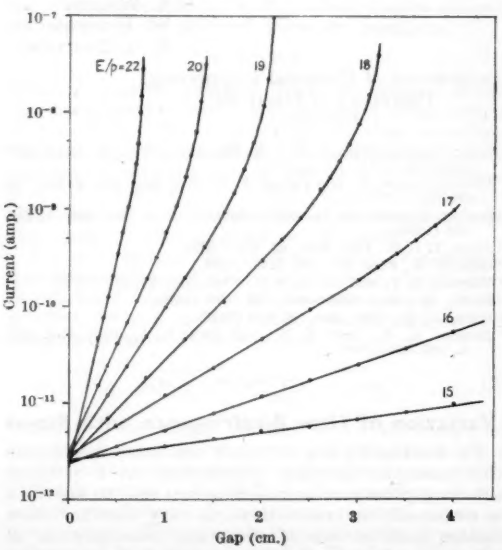

Fig 1. Hydrogen at pressure of 700 mm. of mercury and temperature of 20° C.

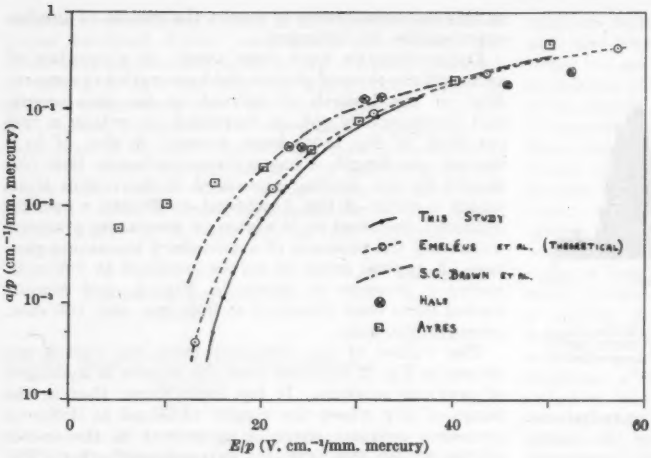

Fig. 2

Assuming the Townsend-type equation

$$i = i_0 \frac{\exp \alpha d}{1 - \gamma (\exp \alpha d - 1)}$$

to describe the form of the $d - \ln i$ plots, values of γ have been evaluated for each experimental point on the non-linear part of the curve, and reasonably consistent values are obtained for all points on any one given curve. When these values of γ, together with the measured values of α/p, are substituted into the Townsend equation, values of pd at breakdown in good agreement with measured values are obtained.

If the measured values of α/p are substituted into the streamer equation in order to calculate breakdown voltages, it is found that the streamer criterion is considerably in error, and that in fact the criterion is only satisfied when over-voltages of the order of 10 per cent are applied.

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Variation of Flow Birefringence with Stress

In flowing liquids in which the same mechanism (for example, network deformation in a polymer solution) gives rise to birefringence and to stress, it is reasonable to expect these to vary together when factors such as rate of shear and concentration of solute are altered. Birefringence and stress require, for their complete description, ellipsoids, and the question arises as to how these are to be compared. According to the simplest possible relation (in which the stress tensor is equal to a constant multiple of the refractive index tensor plus an isotropic tensor), the optic and stress ellipsoids have the same orientation, and the differences of principal axes of either ellipsoid are proportional to the differences of the corresponding principal axes of the other ellipsoid. Thus for coaxial ellipsoids, which we shall consider here, it seems natural to compare differences of principal axes.

In stationary laminar shear flow, the symmetry of flow ensures that two principal axes of each ellipsoid lie in a plane containing the direction of flow and the velocity gradient (Fig. 1). Using light rays normal to this plane, the difference, Δn, of principal semi-axes and the orientation, χ, of the optic ellipsoid can be measured directly. A recently developed technique[1] enables one to measure the corresponding quantities Δp, χ for the stress ellipsoid in solutions of suitable consistency. Such optical and stress measurements have not yet been made on the same liquid, so for the present we shall use the assumption of coaxiality of the ellipsoids to calculate Δp, the difference of principal stresses, from the measured shear stress τ and the optical extinction angle χ, using the relation

$$\Delta p = 2\tau \operatorname{cosec} 2\chi \qquad (1)$$

known from plane stress analysis[9].

It is therefore to be expected that the ratio

$$\frac{\Delta n}{\Delta p} = \frac{\Delta n \sin 2\chi}{2\tau} \qquad (2)$$

will have simple properties.

For Newtonian liquids, $\chi = 45°$ for the stress ellipsoid; hence $\sin 2\chi = 1$ and $2\Delta n/\Delta p = \Delta n/\tau$, which is the 'Maxwell constant' introduced in the early theory of Raman and Krishnan[3] for this case. Optical measurements also give $\chi = 45°$ for most liquids at low shear rates, but values less than 45° at higher shear rates. Similar results for the stress have been found recently[1] for various polymer solutions. This is consistent with the assumption of coaxiality.

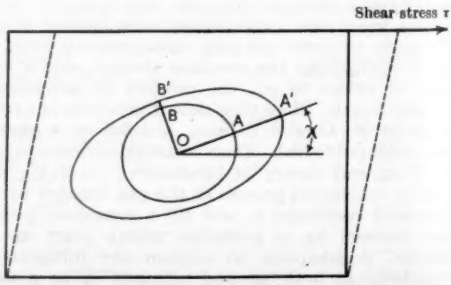

Fig. 1. Sections of coaxial optic (AB) and stress ($A'B'$) ellipsoids in shear flow. $OA - OB = \Delta n$; $OA' - OB' = \Delta p$

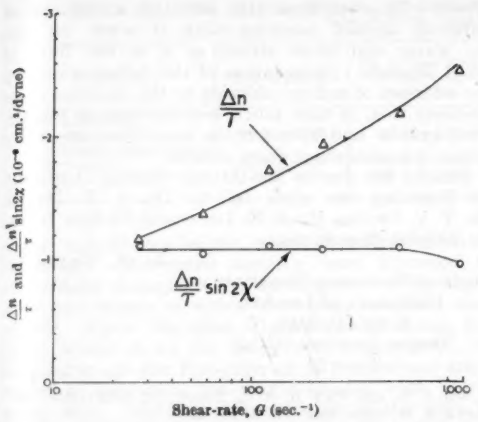

Fig. 2. Flow birefringence of polystyrene ('viscosity average' mol. weight, 200,000) in benzene; 6 per cent solution at 20° C. (Data of Signer, ref. 4)

Measurements of birefringence and shear stress have often been used[4] for calculating the ratio $\Delta n/\tau$ even when χ differs from 45°; but the ratio $\Delta n \sin 2\chi/\tau$ does not appear to have been calculated, despite the strong hint in this direction given by Buchheim and Philippoff[5]. Using published data[4,6] on moderately concentrated polystyrene solutions in various solvents, I have calculated this ratio and find that it is independent of shear rate, polymer concentration, and distribution of chain-length over considerable ranges of these variables. Moreover, the effect of omitting the factor $\sin 2\chi$, when significant, is deleterious: a striking example of this is given in Fig. 2. In these examples, the birefringence of the solvent is negligible in comparison with that of the polymer, so we take $\tau = G(\eta - \eta_0)$, the shear stress due to the polymer, where G denotes shear rate and η, η_0 the solution and solvent viscosities.

Thus the data on certain polystyrene solutions are consistent with the view that the stress and optic ellipsoids are coaxial, that their orientation increases with shear rate, and that the difference of principal axes of the optic ellipsoid increases in proportion to the difference of the corresponding principal axes of the stress ellipsoid.

These results agree with a recent 'molecular' theory[7] in which stress and birefringence in a moderately concentrated flowing polymer solution are assumed to arise from network deformation; this theory leads to the results that the stress and optic ellipsoids are coaxial for any flow history at constant temperature, and that, in shear flow,

$$\frac{\Delta n}{\Delta p} = \frac{\Delta n \sin 2\chi}{2G(\eta - \eta_0)} = \frac{2\pi}{45} \frac{(n^2+2)^2}{n} \frac{\alpha_1 - \alpha_2}{kT} \qquad (3)$$

where n denotes the mean refractive index of the solution, k Boltzmann's constant, T the absolute temperature, α_1 and α_2 the longitudinal and transverse principal polarizabilities of an 'equivalent random link' of the polymer chain. Kuhn and Kuhn have developed a theory for very dilute polymer solutions in which the deformation and orientation of polymer molecules are caused by hydrodynamic forces; using their expressions[8] for Δn, χ and η for flexible molecules to calculate $\Delta n/\Delta p$, I find exactly the same equation (3).

This work forms part of the programme of fundamental research undertaken by the British Rayon Research Association.

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June 16.

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Oscillating Droplets and Spontaneous Emulsification

The observations of Lewis and Pratt[1] and later of Lewis[2] on mass transfer and interfacial stability have led, at these authors' instigation, to our investigating the phenomena in greater detail.

We were able to produce an oscillation in a pendent drop of water in toluene by squirting acetone from a capillary at one side only of the drop. The arrival of the acetone at the interface immediately caused the drop to kick violently towards the capillary. This experiment was repeated with an air bubble in toluene and gave similar results. If, on the other hand, both water droplets and air bubbles are surrounded by a homogeneous solution of acetone in toluene, the water droplets oscillate; but the air bubbles show no movement whatever. An essential condition for oscillations thus appears to be a non-uniform distribution of solute around the drop; this may either be induced by squirting, as above, or by non-uniform diffusion across the interface. The effect of localized changes of interfacial tension resulting from variations of solute concentration around the drop can be deduced from the equation:

$$p = 2\gamma/r \qquad (1)$$

where p is excess pressure inside the drop, γ is the interfacial tension and r is the curvature of the surface of the drop. The equation shows that a sudden decrease in γ over a given area will produce either an impulse outward through this area, or a decrease in r for the same area. These expectations are in agreement with our experimental observations, and also those of Garner, Nutt and Mohtadi[3].

In an attempt to consider this phenomenon quantitatively, we have equated the localized interfacial energy changes to the potential energy of the pendent drop in its displaced position, and on this basis have derived the equation

$$M^*\left(\frac{dc}{d\gamma}\right)^* = \frac{A}{gh} \cdot \frac{c^*}{(1+\alpha)} \qquad (2)$$

where h is the height through which the centre of gravity of the drop rises during a kick and c is the initial solute concentration in the phase from which diffusion occurs; $(dc/d\gamma)^*$ is the gradient of the (solute concentration)–(interfacial tension) curve at the point c^*. (The asterisks imply that the quantities correspond to a kick of size h.) Further, M^* is the relative mass of the drop; α is the distribution

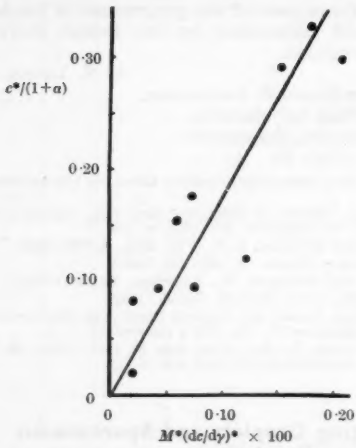

Fig. 1. Plot of $c^*/(1 + \alpha)$ against $M^*(dc/d\gamma)^* \times 100$ for various systems, each consisting of two phases with a third component soluble in both. All experiments were carried out at 20° C.

coefficient for the solute between the two phases and A is the area over which a local change in γ occurs.

By projecting the magnified image of the drop on to a screen, its oscillations were more easily studied and it was found possible to keep h the same (and small) for each system. The factors M^*, $(dc/d\gamma)^*$, and $c^*/(1 + \alpha)$ were determined for each of ten different solute–solvent systems and $c^*/(1 + \alpha)$ plotted against $M^*(dc/d\gamma)^*$ (Fig. 1). Since the line is approximately linear, A can vary very little from system to system. The presence of a detergent in the aqueous phase was found by Lewis greatly to reduce the violence of the oscillations, and in the present work 0·49 mM sodium dodecyl sulphate increased c^* considerably for the acetone-toluene/water system. The point $M^*(dc/d\gamma)^*$, $c^*/(1 + \alpha)$, for this case, however, did not lie on the line of the other results. A probable explanation is that the area A over which the excesses of acetone spread was largely confined by the pressure of the detergent film. This aspect is being investigated.

Since increased transference-rates were observed by Lewis[3] for systems showing interfacial turbulence, investigations have been made on the basis of a suggestion by Quincke[4] that interfacial turbulence is the cause of spontaneous emulsification. If an emulsion were formed at the interface, the surface area would be increased and an increased rate of transference would be expected. Of the systems examined, only those containing alcohol visibly produced emulsions together with kicking of the interface. It is possible, however, to prevent the kicking by the addition of small amounts of protein or detergents without preventing the spontaneous emulsification. The conclusion is, therefore, that spontaneous emulsification is not related to kicking and proceeds according to the mechanism proposed by McBain and Woo[5]. This involves the idea of a column of diffusing alcohol carrying with it some oil into the water and there stranding it in the form of small droplets. Retardation of the diffusion-rate by the addition of sodium chloride to the aqueous phase confirms this, in that much less emulsion is formed. Photographs and slow-motion ciné-films are being taken demonstrating these effects.

Thanks are due to the Atomic Energy Authority for financing the work and to Dr. J. T. Davies, Mr. T. V. Davies, Mr. J. B. Lewis and Sir Eric Rideal for helpful discussions.

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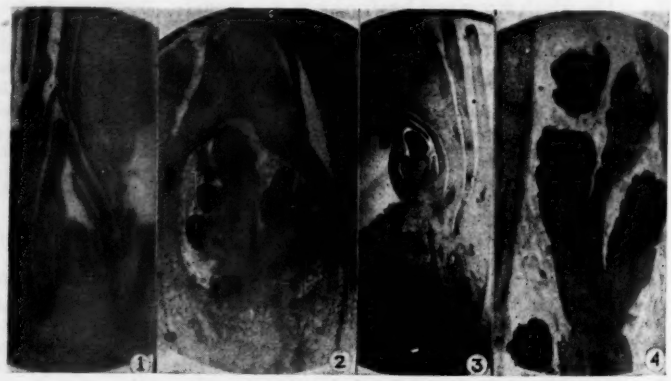
Effect of Auxins on the Flowering Behaviour of Rice

In a recent paper, Hussey and Gregory[1] reported that in two experiments out of four carried out, low concentration of auxin increased the number of flower primordia, while high concentration decreased it in winter barley. These results confirm the findings of Leopold and Thimann[2] in winter barley; but in petukus rye the flowering behaviour was not affected by the auxin treatment. In discussing these results, Hussey and Gregory defined the meaning of flower initiation and promotion of flowering, and expressed the opinion that auxin had no effect on the initiation of flowering, as auxin injection in an unfavourable photoperiod did not show initiation of flower primordia.

In rice, a different picture is obtained. Rice seeds, var. Rupsail, were sown on July 13, 1953, and 500 p.p.m. indole acetic acid and 300 p.p.m. α-naphthalene acetic acid were sprayed to the plants daily for one week from September 10. At the end of the treatment, the plants were allowed to continue



Longitudinal sections of shoot apices of rice. × 360.
(1) Vegetative apex in control on Sept. 20, 1953; (2) differentiating shoot apex of plants treated with indole acetic acid (Sept. 21); (3) control on Sept. 25; (4) differentiation (Sept. 25) of flower initials of plants treated with indole acetic acid

Table 1. Effect of Auxins on Leaf Number, Ear-Emergence, Ear-Length and Number of Spikelets on the Main Shoot. Sowing Date, July 13, 1953. Replications, 15

Treatment	No. of leaves	No. of days from sowing to ear-emergence	Ear-length (cm.)	Total No. of spikelets	No. of empty spikelets	No. of grains set per ear
Indole acetic acid (500 p.p.m.)	15·2 ± 0·33	95·9 ± 2·72	6·76 ± 0·53	65·1 ± 2·35	34·3 ± 2·88	29·4 ± 1·52
α-Naphthalene acetic acid (300 p.p.m.)	15·6 ± 0·36	104·6 ± 2·80	5·90 ± 0·48	54·9 ± 2·18	36·0 ± 1·95	19·4 ± 1·66
Control	17·4 ± 0·37	123·0 ± 1·80	6·95 ± 0·30	90·2 ± 1·88	22·2 ± 0·64	68·0 ± 1·62

under natural day-length, which is unfavourable to flowering. Microtome sections were prepared to study daily changes in the development of the shoot apex, the details of which have been described elsewhere[3]. Up to the time of the hormone spray, the shoot apices in all the cases were vegetative. On September 13 the first sign of a transitional stage began to appear in the plants treated with indole acetic acid. The full differentiation of the apex in plants treated with auxin took place much earlier than those of the control (Figs. 1–4).

Table 1 shows that plants treated with indole acetic acid flowered an average of 27·1 days earlier, and plants treated with naphthalene acetic acid are earlier by 18·4 days. The total number of spikelets was rather adversely affected by the treatment, while the differences in ear-length are not significant. It is evident that the treatment caused a significant reduction in the percentage of grain setting.

Preliminary experiments with only one concentration, fairly high, show that flower primordia are initiated earlier; but the promotion of flowering as visualized by Leopold and Thimann in the formation of an increased number of flowers was not seen. An after-effect of auxin is increased sterility in the spikelets.

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Gene Control of Copper-Sensitivity in *Saccharomyces*

An extensive study of the adaptation of yeasts to copper by Prof. Joji Ashida and his associates[1] revealed that yeasts are trained to high concentrations of copper by a two-step process. On agar containing copper, they found that copper-sensitive yeast cells grew as a thin film which became spotted with brown colonies of copper-resistant cells. Cells which they selected from the brown colonies proliferated rapidly on transfer to a copper medium, producing dense brown subcultures. Studies by the Ashida group indicated that many factors affect pigmentation of the copper-resistant cells. They inferred that the ability to resist copper-poisoning could be transferred to sensitive cells by ribonucleic acid extracted from closely related resistant organisms, but not by ribonucleic acid from sensitive organisms. They showed that the difference between resistant and sensitive cells was clearly expressed in medium containing 1 m*M*/l. of copper sulphate. In the cultures of *Saccharomyces* tested by Ashida and his group copper-resistant variants did not arise without training; none grew rapidly on a copper medium without previous selection by the two-step process described above.

Eighteen cultures of the Carbondale breeding stock (a stock developed by the hybridization of six different species of *Saccharomyces*) were tested for resistance to copper in broth cultures. All but one were resistant. The medium was supplemented with 1 m*M*/l. of copper sulphate and contained 4 ml. of liquid yeast extract (Anheuser–Busch), 3·5 gm. of peptone, 1·0 gm. of magnesium sulphate, 2·0 gm. of potassium dihydrogen phosphate, 40·0 gm. of dextrose, 1,000 ml. of distilled water. The *p*H was adjusted to 5·5 in a Beckman *p*H meter. The conclusions of the Ashida group that 1 m*M*/l. is a satisfactory concentration for distinguishing copper-resistant from copper-sensitive cultures were confirmed. 4 ml. of broth containing copper was inoculated with 300–500 cells from a 24-hr. copper-free slant. The resistant cultures grew rapidly in the copper-broth, whereas the sensitives failed to produce perceptible growth in 24 hr. Stock cultures were maintained on copper-free medium, and transfers from the copper-containing medium were never used in the hybridization programme. Genetical analysis was confined to the single original gene-pair controlling copper-resistance and copper-sensitivity, and no attempt was made to discover if other gene pairs were involved in the control of copper-sensitivity, since more than one gene controlling the same phenotype cannot be used in a programme aimed at chromosome mapping.

The original sensitive culture was mated to a resistant culture and eleven asci were dissected and tested for sensitivity to copper. Two sensitive and two resistant cultures were obtained from each ascus, indicating that the character is gene-controlled. The hybrid (family I) was heterozygous for genes controlling mating type and galactose fermentation. Four families heterozygous for the gene-pair controlling resistance and sensitivity to copper, as well as for genes controlling mating-type, fermentation of galactose, sucrose and melibiose, and synthesis of proline, *iso*leucine, uracil and lysine, were analysed. The pedigree is shown in Fig. 1. No linkage between the gene-pair controlling sensitivity to copper and other genes was found. Regular segregation occurred in all asci for all the markers indicated except for one ascus in family III which produced three *iso*leucine-independent and one *iso*leucine-dependent clone, and one ascus in family IV which produced three uracil-dependent and one uracil-independent clone. In all, a total of fifty-seven asci were analysed. In eight asci only three spores survived and the composition of the missing spore was inferred. Hybrids homozygous for either sensitivity or resistance produce only progeny which resemble their parents in this respect.

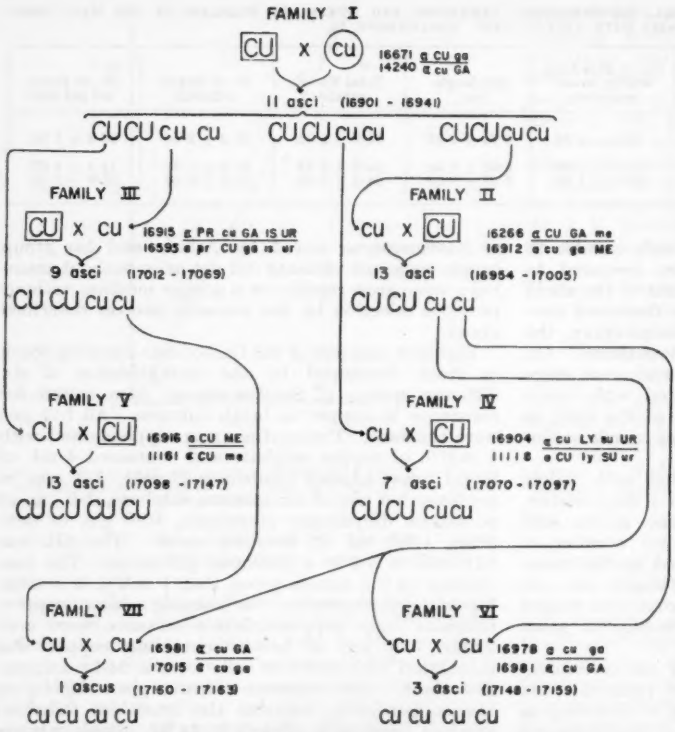

Fig. 1. Pedigree of Copper-resistance and Copper-sensitivity

The designations enclosed in squares or circles indicate cultures selected by canvassing the breeding stocks. The genotypes of the hybrids and the serial numbers of the parent stocks are indicated to the right of each. The abbreviations are: *a/a*, mating type; *CU/cu*, copper sensitivity; *GA/ga*, galactose fermentation; *ME/me*, melibiose fermentation; *PR/pr*, proline requirement; *IS/is*, isoleucine; *UR/ur*, uracil; *LY/ly*, lysine; *SU/su*, sucrose. The number of asci isolated from each hybrid and their serial numbers are indicated. Three asci from family I provided parent cultures for families II, III, IV and V as indicated by the arrows

This work has been supported by a research grant from the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service, *C*-2140.

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June 9.

[1] Minagawa, T., Yanagishima, N., Arakatsu, Y., Nagasaki, S., and Ashida, J., *Bot. Mag. Tokyo*, **64**, 753 (1951); **65**, 771 (1952); **66**, 775 (1953). Naiki, N., Minagawa, T., Arakatsu, Y., and Ashida, J., *Mem. Coll. Science, Univ. Kyoto*, B, **21**, 87 (1954). Arakatsu, Y., Yanagishima, N., Minagawa, T., Naiki, N., and Ashida, J., *Mem. Coll. Sci., Univ. Kyoto*, B, **21**, 97 (1954).

An Electrified Barrier for Caterpillars

Plant-feeding caterpillars are often difficult to rear in the laboratory owing to their wandering habits. Cages which will contain the caterpillars, particularly in the young stages, must be of such fine mesh that the whole environment is altered and becomes unsuitable for both plant and insect. The wandering propensities of the insects are often accentuated by the unsuitable conditions. These difficulties have been overcome, in the case of the cutworm *Persectania aversa*, by the development of an electrified barrier. This barrier may be only two inches high and makes little alteration to the environment while effectively preventing the escape of the caterpillars.

The main difficulty in making an electrified barrier to contain small insects lies in the need to have a very narrow gap between the two conducting elements. A single electrified wire close to the ground is unsuitable, since any slight unevenness in the soil surface will cause a short-circuit. Short-circuits can be avoided by placing two conducting elements on a vertical wooden or metal frame.

Aluminium foil, which is cheap and easy to handle, is used for the conducting elements. A strip of foil 2–2½ in. wide is glued to thick brown paper. When dry it is cut into two strips; a guillotine is best for this as it ensures that the edges of the foil and paper are flush with each other over their whole length. The two paper-backed strips are then glued to a wider strip of brown paper so that one overlaps the other by ¼ in. The two strips are thus insulated from each other by one thickness of brown paper, but provide a barrier 1¼ in. wide. The whole completed barrier is then glued to a wooden or metal frame which is embedded in the soil of the rearing container. The brown paper provides a gap small enough to stop the smallest caterpillars, but with sufficient insulation for the low voltages used.

Owing to this narrow gap, high voltages cannot be used. It would be necessary to determine the minimum voltage for each individual insect. For *P. aversa*, 6 V. is the lowest voltage which will stop the insects without killing them. The barriers in use at the moment carry 12 V. a.c. obtained by the use of a radio transformer. Direct current is less satisfactory, for although it will stop the caterpillars there is a tendency for many to stick across the two elements and be killed.

A vertical barrier is preferable, for the caterpillars can recoil more easily after making contact. Many of them drop straight back to the ground. On a horizontal barrier they are more likely to be killed by their inability to recoil quickly.

In addition to its use for preventing the escape of caterpillars, this barrier might be used to prevent them entering a control plot. In this case the electrified elements would need to be placed on the outside of the frame.

This equipment has not yet been tried with other insects. This will be done shortly, and a full description, together with methods of testing the barrier, will be published later.

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June 13.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 31

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 2.30 p.m.—Mr. E. D. R. Shearman: "The Technique of Ionospheric Investigation using Ground Back-Scatter" and "A Study of Ionospheric Propagation by means of Ground Back-Scatter"; Mr. R. W. Meadows: "An Experiment to Test the Reciprocal Radio Transmission Conditions Over an Ionospheric Path of 740 km."; Mr. J. F. M. Laver and Mr. H. Stanesby: "An Experimental Test of Reciprocal Transmission Over Two Long-Distance High-Frequency Radio Circuits" At 5.30 p.m.—Mr. W. J. Bray, Dr. J. A. Saxton, Mr. R. W. White and Mr. G. W. Luscombe: "V.H.F. Propagation by Ionospheric Scattering and its Application to Long-Distance Communication".

Monday, October 31—Thursday, November 3

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (in collaboration with the ASSOCIATION OF BRITISH INSECTICIDE MANUFACTURERS, the BRITISH AGRICULTURAL CONTRACTORS' ASSOCIATION, the NATIONAL ASSOCIATION OF CORN AND AGRICULTURAL MERCHANTS, and the NATIONAL FARMERS' UNION, at Eastbourne)—National Crop Protection Conference—"Practical Aspects of the Use of Insecticides and Fungicides in Agriculture and Horticulture".

Tuesday, November 1

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. Hannah Steinberg: "Drugs and Psychological Time".*

UNIVERSITY OF LONDON, BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. M. M. Swann: "Physiology of Mitosis". (Second of fifteen Lectures on "The Scientific Basis of Medicine.")*

Wednesday, November 2

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. D. V. Ager: "The Geographical Distribution of Brachiopods in the British Middle Lias"; Dr. J. H. James: "The Structure and Stratigraphy of Part of the Pre-Cambrian Outcrop between Church Stretton and Linley, Shropshire".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. F. N. David and Dr. N. L. Johnson: "Some Tests of Significance with Ordered Variables".

UNIVERSITY OF LONDON (in the Senate House, Malet Street, London, W.C.1), at 5.30 p.m.—Sir David Brunt, F.R.S.: "Retrospect and Prospect in Meteorology" (Meteorological Office Centenary Lecture).*

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. T. M. Harris: "Mesozoic Plants". (Further Lectures on November 9 and 16.)*

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATES AND STUDENTS SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Dr. E. Colin Cherry: "Communication of Information—Human, Animal and Machine".

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Meeting on "The Evaluation of Anti-fungals".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 7.30 p.m.—Symposium: "Who Doesn't Answer". A symposium on the problem of bias through non-return in questionnaire surveys and follow-up conducted by post.

Wednesday, November 2—Friday, November 4

BRITISH INSTITUTE OF MANAGEMENT (at Harrogate)—National Conference—"The Impact of Science on Management in the Future".

Thursday, November 3

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1, at 4.30 p.m.—Mr. H. G. Thornton, F.R.S.: "The Ecology of Micro-organisms in Soil" (Leeuwenhoek Lecture).

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. H. Graham Cannon, F.R.S.: "What Lamarck Really Said!".

MINERALOGICAL SOCIETY (in the apartments of the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Barnes Hall, Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 5 p.m.—Lord Adrian, O.M., F.R.S.: "The Action of the Mammalian Olfactory Organ" (Semon Lecture).*

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Captain C. F. Booth and Mr. B. N. MacLarty: "The New High-Frequency Transmitting Station at Rugby".

UNIVERSITY OF LONDON, BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. H. G. Davies: "The Use of the Interference Microscope in Biological Research". (Third of fifteen Lectures on "The Scientific Basis of Medicine.")*

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Friday, November 4

ASSOCIATION OF APPLIED BIOLOGISTS (in the Meeting Room of the Royal Entomological Society of London, 41 Queen's Gate, South Kensington, London, S.W.7), at 11 a.m.—Meeting on "Some Recent Researches on Fruit Growing".

UNIVERSITY OF LONDON (at Charing Cross Hospital Medical School London, W.C.2), at 5 p.m.—Dr. J. Hammond: Growth in Animals".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Graham Sutton, F.R.S.: "Weather Forecasting—the Future Outlook".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PHYSICAL or INDUSTRIAL CHEMISTS or CHEMICAL ENGINEERS (with good honours degree or equivalent qualifications, preferably with experience), for research in the processing of coal and allied materials covering a wide field of physical chemistry and chemical engineering, including laboratory investigations into the surface characteristics and associated properties of coal and allied materials, and the design and operation of pilot plant—National Coal Board, Central Research Establishment, Stoke Orchard, near Cheltenham, Glos, quoting SS/93 (November 4).

BIOCHEMIST, senior grade (with B.Sc. degree and/or A.R.I.C. and with wide general experience in medical biochemistry)—Group Secretary, Group 20 Hospital Management Committee, Stoney Stanton Road, Coventry (November 5).

LECTURER or ASSISTANT LECTURER IN ANATOMY—Registrar, The University, Manchester 13 (November 7).

SENIOR LECTURER and LECTURER (with good honours degree and preferably with teaching experience) IN PHYSICS at the Nigerian College of Arts, Science and Technology—Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (November 7).

RESEARCH ASSISTANT (with a good honours degree in biochemistry or in chemistry and physiology) IN THE PHARMACOLOGY DEPARTMENT—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (November 11).

ASSISTANT (with interest in algology) IN BOTANY—The Secretary, The University, Aberdeen (November 12).

ASSISTANT ECONOMIST (with a university degree in economics, and preferably with postgraduate experience) at the Colonial Office, for duties including the review of economic trends and progress, economic analysis of colonial development plans, economic intelligence, research studies and to provide advice and assistance in economic fields to other departments of the Colonial Office—London Appointments Officer, Ministry of Labour and National Service, 1–6 Tavistock Square, London, W.C.1, quoting AC.1218 (November 12).

CHAIR OF ZOOLOGY—The Registrar, University College, Singleton Park, Swansea (November 12).

COMPUTER (with at least G.C.E., including mathematics at advanced level) IN MATHEMATICAL STATISTICS AND SOME APPLIED MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (November 12).

ENGINEERING ASSISTANT (graduate, with at least two years practical experience of civil engineering work) IN THE HIGHWAY PLANNING SECTION, for duties in connexion with the realignment of roads, preliminary reconnaissance of new major highway routes and the control of main roadside access—County Planning Officer, Litton Lodge, Clifton Road, Winchester (November 12).

LECTURER IN PHYSIOLOGY—The Dean, St. Bartholomew's Hospital Medical College, West Smithfield, London, E.C.1 (November 12).

LECTURER IN PSYCHOLOGY—The Secretary, The University, Aberdeen (November 14).

SCIENTIFIC OFFICER (with first- or second-class honours degree in chemistry or chemical engineering, or equivalent qualification, with wide interest in the application of science rather than in academic research, a broad appreciation of the scientific aspects of industrial problems and an aptitude for dealing with people, preferably with industrial experience) AT THE HEADQUARTERS INTELLIGENCE DIVISION, Directorate of Scientific and Industrial Research, London, to collect and collate information, both from literature and personal visits, on technical developments of current importance—Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.620/54 (November 14).

AERODYNAMICISTS and MATHEMATICIANS, Scientific Officer grade (with first- or second-class honours degree or equivalent qualification, preferably with some research or development experience), at Ministry of Supply Experimental Establishments, mainly at Amesbury, Farnborough, Bedford and London Headquarters, for research and development work on aircraft projects, problems of auto-control, flight test and performance analysis, guided weapons and gas turbines—Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.753/5A (November 15).

LECTURER or ASSISTANT LECTURER IN GEOGRAPHY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 15).

LECTURER IN PHARMACOLOGY—The Registrar, King's College, Strand, London, W.C.2 (November 15).

SCIENTIFIC OFFICER (with an honours degree in chemistry with postgraduate experience in agricultural chemistry or an honours degree in agricultural chemistry) IN THE CHEMICAL RESEARCH DIVISION, Ministry of Agriculture, Northern Ireland, to take part in research investigations and the general duties of the Division, and possibly to undertake teaching duties in the Faculty of Agriculture, The Queen's University—Director of Establishments, Ministry of Finance, Stormont, Belfast, N. Ireland (November 16).

PHYSIOLOGIST or BIOCHEMIST (with an honours degree in science or equivalent qualification with physiology or biochemistry as major subject and preferably with postgraduate research experience in the

fractionation and biological assay of protein hormones) as Research Officer at the Sheep Biology Laboratory, Prospect, N.S.W., Australia, to undertake investigations on the endocrinology of wool growth—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 205/86 (November 19).

Plant Physiologist (with an honours degree and postgraduate training and experience in plant physiology)—The Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle, Ceylon (November 19).

Senior Lecturer or Lecturer in Bacteriology—The Registrar, The University, Manchester 13 (November 19).

Senior Lecturer in Physics at Victoria University College, Wellington, New Zealand—Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 21).

Research Officer (with a first- or good second-class honours degree with qualifications in agricultural chemistry and experience in field experimentation) at Dunholme Field Station, Lincoln, to organize a series of field experiments on the manuring of sugar beet—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (November 26).

Director of the West African Institute of Social and Economic Research, University College, Ibadan—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (November 30).

Fellow and Senior Research Fellow (to undertake research in mathematical statistics or its applications, including mathematical genetics) in the Department of Statistics, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

Lecturer in Applied Mathematics at St. Salvator's College—Joint Clerk to the University Court, The University, St. Andrews (November 30).

Lecturer (with an honours degree in geography and with special qualifications in physical and economic geography and geomorphology) in Geography, at St. Salvator's College—Joint Clerk to the University Court, The University, St. Andrews (November 30).

Lecturer or Assistant Lecturer (preferably with special interest in petrology, mineragraphy or structural geology) in Geology, at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

Reader in Geology—The Registrar, University of Dacca, Ramna, Dacca, East Bengal, Pakistan (November 30).

Demonstrator (graduate in chemistry) in Chemistry—The Registrar, College of Technology, Manchester 1 (December 1).

Senior Lecturer (with a degree in science or engineering with geology as a major subject, and with field experience in mining and/or engineering geology, preferably with experience in mineragraphy and/or geophysical exploration) in Geology, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 2).

Lecturer (with a research degree in organic chemistry and experience of teaching this subject) in Organic Chemistry at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (December 9).

Chair of Building Science—The Registrar, The University, Liverpool (December 10).

Chair of Geography at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (December 15).

Stanley Elmore Research Fellowship in Extraction Metallurgy, to undertake research in the Department of Metallurgy of a University or similar Institution in the United Kingdom—Stanley Elmore Trust, 175 Temple Chambers, Temple Avenue, London, E.C.4 (December 31).

Assistant Trials Officer (with a degree in botany or agriculture or equivalent qualification, and with practical experience in crop production) at the Seale-Hayne Agricultural College, Newton Abbot—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Chemical Engineer (with a degree in chemical engineering or equivalent qualifications) on the personal staff of the Chief Engineer, North Thames Gas Board, for duties including development work, particularly in relation to new and improved methods of production, refining and distribution of gas from gaseous and liquid hydrocarbons and coal—Staff Controller, North Thames Gas Board, 30 Kensington Church Street, London, W.8, quoting 666/282.

Editing Librarian to be responsible for the handling, cataloguing and storage of film material—Films Officer, British Transport Commission, 25 Savile Row, London, W.1.

Entomologists (with an honours degree in zoology and training in entomology) in the Department of Tsetse Control, Gold Coast, to investigate various aspects of the bionomics and ecology of tsetse flies in relation to man and animals, and to supervise control measures under the Director of Tsetse Control—Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.77/13/01.

Senior Experimental Officer or Experimental Officer (with at least H.S.C. Science or equivalent qualification, with a general scientific and engineering background and a working knowledge of radioactivity measuring apparatus, remote handling, health physics, machine shop and experimental construction of equipment) in the Isotopes Division, for duties including the preparation of materials and the arrangement of irradiations with Pile Groups, high-level remote handling and measurements, developments of techniques and mechanical, electrical and electronic equipments—Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/108/409.

Senior Instructor (with academic qualifications and sound workshop training and with teaching experience) at the Staff Training College, Derby, to prepare, supervise and take part in courses of instruction for various grades of staff who will be engaged in designing, maintaining and repairing locomotives and rail-cars having diesel engine propulsion with hydraulic, mechanical, electrical or other transmission and control—Manpower Adviser, British Transport Commission, 222 Marylebone Road, London, N.W.1.

Senior Scientific Officer (honours graduate with a sound knowledge of statistical methods and preferably with industrial and technical experience) for work including research into problems connected with the coking industry, preparation of technical reports and possible participation in operational research in the provinces; Scientific Officer (graduate with some industrial and/or technical experience) for general technical duties and the preparation and editing of technical reports—The Secretary, British Coke Research Association, 74 Grosvenor Street, London, W.1.

Training Manager (honours graduate with qualification in physics or chemistry or Associate Member of a senior Engineering Institution) for the United Kingdom Atomic Energy Authority, Industrial Group, Capenhurst Works, for training activities within the works with the assistance of a small staff, and to maintain close liaison with local Education Authorities and Technical Colleges—Recruitment Officer, U.K. Atomic Energy Authority, Industrial Group Headquarters, Risley, near Warrington, quoting 1,132.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Committee on Air Pollution. Report. (Cmd. 9322.) Pp. 80. (London: H.M. Stationery Office, 1955.) 2*s.* 6*d.* net. [38

Clean Air Bill. (Bill 40.) Pp. iv+28. (London: H.M. Stationery Office, 1955.) 1*s.* net. [38

The Commonwealth and Nuclear Development. (Central Office of Information Reference Pamphlet—No. 2.) Pp. iv+52. (London: H.M. Stationery Office, 1955.) 2*s.* net. [38

Education in 1954: being the Report of the Ministry of Education and the Statistics of Public Education for England and Wales. (Cmd. 9521.) Pp. viii+197. (London: H.M. Stationery Office, 1955.) 7*s.* 6*d.* net. [38

The South-Eastern Naturalist and Antiquary. (Being the Fifty-ninth volume of transactions of the South-Eastern Union of Scientific Societies, including the Proceedings at the Fifty-ninth Annual Congress held at Maidstone, 1954. Edited by L. R. A. Grove. Pp. xxvi+56. (Maidstone: Mr. L. R. A. Grove, Museum and Art Gallery, 1954.) 6*s.* 6*d.* net. (Free to members.) [108

Ministry of Agriculture and Fisheries. Bulletin No. 56: Poultry Housing. Fifth edition. Pp. iv+56+4 plates. (London: H.M. Stationery Office, 1955.) 2*s.* 6*d.* net. [108

Ministry of Fuel and Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act, 1911, for the year 1954. North Eastern Division. By C. W. Scott. Pp. ii+34+4 plates. (London: H.M. Stationery Office, 1955.) 2*s.* net. [108

Building Research Station Digest. No. 79 (July, 1955): Internal Corrosion of Concrete Sewer Pipes by Effluents Containing Sulphates. The Treatment of Walls Infected with Dry Rot. Repair to Mastic Asphalt and Felt Roof Coverings. Pp. 4. (London: H.M. Stationery Office, 1955.) 3*d.* net. [108

Other Countries

Government of India: Meteorological Department. Report on the Administration of the Meteorological Department of the Government of India in 1951–1952. Pp. 62+3 plates. (Simla: Government of India Press, 1954.) [108

Museums Trustees of Kenya. Coryndon Memorial Museum, Nairobi. Annual Report for 1954—(1) Chairman's Report; (2) Curator's Report. Pp. 24+3 plates. (Nairobi: Coryndon Memorial Museum, 1955.) 1*s.* [108

Research Bulletin of the Panjab University. No. 63 (Zoology): A Preliminary Note on some Birds of the Hoshiarpur District, Panjab, (1). By G. P. Sharma and B. S. Lamba. Pp. 177–186. Rs. 1/2/–. No. 64 (Zoology): Spermatogenesis of a Digenetic Trematode (*Cotylophoron Elongatum*. By Om. Parkash Dhingra. Pp. 1–10. Rs. 1/10/–. No. 65 (Zoology): Spermatogenesis of a Digenetic Trematode *Gastrothylax Crumenifer*. By Om. Parkash Dhingra. Pp. 11–17. Rs. 1/4/–. No. 66 (Zoology): Gametogenesis, Fertilization and Cleavage in *Asymphylodora* SP. By Om. Parkash Dhingra. Pp. 19–29. Rs. 1/13/–. No. 67 (Mathematics): Partitions in General. By Hansraj Gupta. Pp. 31–38. Rs. 1/5/–. No. 68 (Zoology): Oogenesis of the Toad, *Bufo Stomaticus* Lutken, with observations under the Phase Contrast Microscope. By Vishwa Nath and S. K. Malhotra. Pp. 39–46. Rs. 3/–/–. No. 69 (Zoology): Studies on Insect Spermatogenesis of *Chrotogonus trachypteris* (Blanch) with observations under the Phase Contrast Microscope. By Sukhdev Raj Bawa. Pp. 47–54. Rs. 1/13/–. No. 70 (Zoology): Oogenesis of the Wall-Spider, *Crossopriza Lyoni* (Blackwall), as studied under the Phase Contrast Microscope. By Vishwa Nath and Rajindar M. Dhawan. Pp. 55–62. Rs. 1/8/–. No. 71 (Chemistry): Sodium Meta-Vanadate as Volumetric Reagent. Part 3: Diphenylamine Indicator Method. By Balwant Singh and Ranjit Singh. Pp. 63–66. Rs. 0/12/–. (Hoshiarpur: Panjab University, 1954 and 1955.) [108

Sudan Government: Ministry of Agriculture. Annual Report of the Research Division 1951/52. Pp. ii+192. (Khartoum: Ministry of Agriculture (Research Division), 1954.) [108

American Numismatic Society. Numismatic Notes and Monographs. No. 129: Chemical Composition of Parthian Coins. By Earle R. Caley. Pp. v+104 (3 plates). (New York: American Numismatic Society, 1955.) 2.50 dollars. [108

United States Department of Commerce. Weather Bureau. Technical Paper No. 11: Weekly Mean Values of Daily Total Solar and Sky Radiation. Supplement No. 1. Prepared by Sigmund Fritz. Pp. 4. (Washington, D.C.: Government Printing Office, 1955.) [108